Preliminary conclusions regarding the updated status of listed ESUs of West Coast salmon and steelhead

A. Chinook salmon

February 2003

Co-manager review draft

This section deals specifically with chinook salmon It is part of a larger report, the remaining sections of which can be accessed from the same website used to access this section (http://www.nwfsc.noaa.gov/). The main body of the report (Background and Introduction) contains background information and a description of the methods used in the risk analyses.

A. CHINOOK

A.1 BACKGROUND AND HISTORY OF LISTINGS

Chinook salmon (*Oncorhynchus tshawytscha* Walbaum), also commonly referred to as king, spring, quinnat, Sacramento, California, or tyee salmon, is the largest of the Pacific salmon (Myers et al. 1998). The species historically ranged from the Ventura River in California to Point Hope, AK in North America, and in northeastern Asia from Hokkaido, Japan to the Anadyr River in Russia (Healey 1991). Additionally, chinook salmon have been reported in the Mackenzie River area of Northern Canada (McPhail and Lindsey 1970). Of the Pacific salmon, chinook salmon exhibit arguably the most diverse and complex life history strategies Healey (1986) described 16 age categories for chinook salmon, seven total ages with three possible freshwater ages. This level of complexity is roughly comparable to sockeye salmon (*O. nerka*), although sockeye salmon have a more extended freshwater residence period and utilize different freshwater habitats (Miller and Brannon 1982, Burgner 1991). Two generalized freshwater life-history types were initially described by Gilbert (1912): "stream-type" chinook salmon reside in freshwater for a year or more following emergence, whereas "ocean-type" chinook salmon migrate to the ocean predominately within their first year. Healey (1983, 1991) has promoted the use of broader definitions for "ocean-type" and "stream-type" to describe two distinct races of chinook salmon. This racial approach incorporates life history traits, geographic distribution, and genetic differentiation and provides a valuable frame of reference for comparisons of chinook salmon populations. For this reason, the BRT has adopted the broader "racial" definitions of ocean- and stream-type for this review.

Of the two life history types, ocean-type chinook salmon exhibit the most varied and plastic life history trajectories. Ocean-type chinook salmon juveniles emigrate to the ocean as fry, subyearling juveniles (during their first spring or fall), or as yearling juveniles (during their second spring), depending on environmental conditions. Ocean-type chinook salmon also undertake distinct, coastally oriented, ocean migrations. The timing of the return to freshwater and spawning is closely related to the ecological characteristics of a population's spawning habitat. Five different run times are expressed by different ocean-type chinook salmon populations: spring, summer, fall, late-fall, and winter. In general, early run times (spring and summer) are exhibited by populations that use high spring flows to access headwater or interior regions. Ocean-type populations within a basin that express different runs times appear to have evolved from a common source population. Stream-type populations appear to be nearly obligate yearling outmigrants (some 2-year-old smolts have been identified), they undertake extensive off-shore ocean migrations, and generally return to freshwater as spring- or summer-run fish. Stream-type populations are found in northern British Columbia and Alaska, and in the headwater regions of the Fraser River and Columbia River interior tributaries.

Prior to development of the ESU policy (Waples 1991), the NMFS recognized Sacramento River winter chinook salmon as a "distinct population segment" under the ESA (NMFS 1987). Subsequently, in reviewing the biological and ecological information concerning West Coast chinook salmon, Biological Review Teams (BRTs) have identified additional ESUs for chinook salmon from Washington, Oregon, and California: Snake River fall-run (Waples et al. 1991), Snake River spring- and summer-run (Matthews and Waples 1991), and Upper Columbia River summer- and fall-run chinook salmon (originally designated as the mid-Columbia River summer- and fall-run chinook salmon, Waknitz et al. 1995), Puget Sound chinook salmon, Washington Coast chinook salmon, Lower Columbia River chinook salmon, Upper Willamette River chinook salmon, Middle Columbia River spring-run chinook salmon, Upper Columbia River spring-run chinook salmon, Oregon Coast chinook salmon, Upper Klamath and Trinity rivers chinook salmon, Central Valley fall and late-fall-run chinook salmon, and Central Valley spring-run chinook salmon (Myers et al. 1998), the Southern Oregon and Northern California chinook salmon, California Coastal chinook salmon, and Deschutes River (NMFS 1999).

Of the 17 chinook salmon ESUs identified by the NMFS, eight are not listed under the United States ESA, seven are listed as threatened (Snake River spring- and summer-run chinook salmon, and Snake River fall-run chinook salmon [Federal Register, Vol. 57, No. 78, April 22, 1992, p. 14653]; Puget Sound chinook salmon, Lower Columbia River chinook salmon, and Upper Willamette River chinook salmon [Federal Register, Vol. 64, No. 56, March 24, 1999, p. 14308]; Central Valley fall-run, and California Coastal chinook salmon [Federal Register, Vol. 64, No. 179, September 16, 1999, p. 5039]), and two are listed as endangered (Sacramento River winter-run chinook salmon [Federal Register, Vol. 59, No. 2, January 4, 1994, p. 440], and Upper Columbia River spring-run chinook salmon [Federal Register, Vol. 64, No. 56, March 24, 1999, p. 14308]).

The NMFS convened a BRT to update the status of listed chinook salmon ESUs in Washington, Oregon, California, and Idaho. The chinook salmon BRT[1] met in January of 2003 in Seattle, WA to review updated information on each of the ESUs under consideration.

[1] The Biological Review Team (BRT) for the updated chinook salmon status review included, from the NMFS Northwest Fisheries Science Center: Thomas Cooney, Dr. Robert Iwamoto, Dr. Robert Kope, Gene Matthews, Dr. Paul McElhaney, Dr. James Myers, Dr. Mary Ruckelshaus, Dr. Thomas Wainwright, Dr. Robin Waples, and Dr. John Williams; from the NMFS Southwest Fisheries Science Center: Dr. Peter Adams, Dr. Eric Bjorkstedt, and Dr. Steve Lindley; from the NMFS Alaska Fisheries Science Center (Auke Bay Laboratory): Alex Wertheimer; and from the USGS Biological Resource Division: Dr. Reginald Reisenbichler.

A.2.1 SNAKE RIVER FALL CHINOOK

Snake River fall chinook spawn above Lower Granite Dam in the mainstem Snake River and in the lower reaches of major tributaries entering below Hells Canyon Dam. Adult fall chinook enter the Columbia River in July and August. The Snake River component of the fall chinook run migrates past the Lower Snake river mainstem dams in September and October. Spawning occurs from October through November. Juveniles emerge from the gravels in March and April of the following year. Snake River fall chinook are subyearling migrants, moving downstream from natal spawning and early rearing areas from June through early fall.

Fall chinook returns to the Snake River generally declined through the first half of this century (Irving and Bjornn 1981). In spite of the declines, the Snake River basin remained the largest single natural production area for fall chinook in the Columbia drainage into the early 1960s (Fulton 1968). Spawning and rearing habitat for Snake River fall chinook was significantly reduced by the construction of a series of Snake River mainstem dams. Historically, the primary spawning fall chinook spawning areas were located on the upper mainstem Snake River. Currently, natural spawning is limited to the area from the upper end of Lower Granite Reservoir to Hells Canyon dam and the lower reaches of the Imnaha , Grande Ronde, Clearwater and Tucannon Rivers.

Adult counts at Snake River dams are an index of the annual return of Snake River fall chinook to spawning grounds. Lower Granite Dam is the uppermost of the mainstem Snake River dams that allow for passage of anadromous salmonids. Adult traps at Lower Granite Dam have allowed for sampling of the adult run as well as for removal of non-local hatchery returns.

Lyons Ferry Hatchery was established as one of the hatchery programs under the Lower Snake Compensation Plan administered through the USFWS. Snake River fall chinook production is a major program for Lyons Ferry Hatchery, which is operated by the Washington Department of Fish and Wildlife and is located along the Snake mainstem between Little Goose Dam and Lower Monumental Dam. WDFW began developing a Snake River fall chinook broodstock in the early 1970s through a trapping program at Ice Harbor Dam and Lower Granite Dam. The Lyons Ferry facility became operational in the mid-1980s and took over incubation and rearing for the Snake River egg bank program.

A.2.1.1 Previous BRT Conclusions

Previous chinook status reviews (Myers et al. 1998, Waples et al. 1991) identified several concerns regarding Snake River fall chinook status including: steady and severe decline in abundance since the early 1970s; loss of the primary spawning and rearing areas upstream of the Hells Canyon Dam complex; increase in non-local hatchery contribution to adult escapement over Lower Granite Dam, and relatively high aggregate harvest impacts in ocean and in-river fisheries.

A.2.1.2 New Data and Updated Analyses

A major Snake River fall chinook supplementation effort based upon the Lyons Ferry Snake River fall chinook broodstock has been implemented in recent years (references??). Acclimation facilities adjacent to major natural spawning areas have been used to acclimate release groups of yearling smolts. Additional releases of sub-yearlings have been made, depending on the availability of sufficient broodstock to maintain the on-station program and the off-station yearling releases. Returns in 2000 and 2001 reflect increases in the off-station plants in recent years as well as improved survival after release.

Abundance

The 1999 NMFS Status Review Update noted increases in the Lower Granite Dam counts in the mid-1990s (Figure A.2.1.1), and the upward trend in returns--the 2001 count over Lower Granite Dam exceeded 8,700 adult fall chinook--has continued. The 1997 through 2001 escapements were the highest on record since the count of 1,000 in 1975. Wild chinook returns and hatchery returns from increased production in the Lyons Ferry Hatchery Snake River egg bank stock have provided the bulk of the increase in returns. Returns classified as natural origin exceeded 2,600 in 2001. The 1997-2001 geometric mean natural origin count over Lower Granite Dam was 871 fish. The largest increase in fall chinook returns to the Snake River spawning area was from the Lyons Ferry Snake River stock component. Returns increased from under 200 per year prior to 1998 to over 1,200 and 5,300 adults in 2000 and 2001, respectively. The increase includes returns from the on-station release program as well as returns from large supplementation releases above Lower Granite Dam.

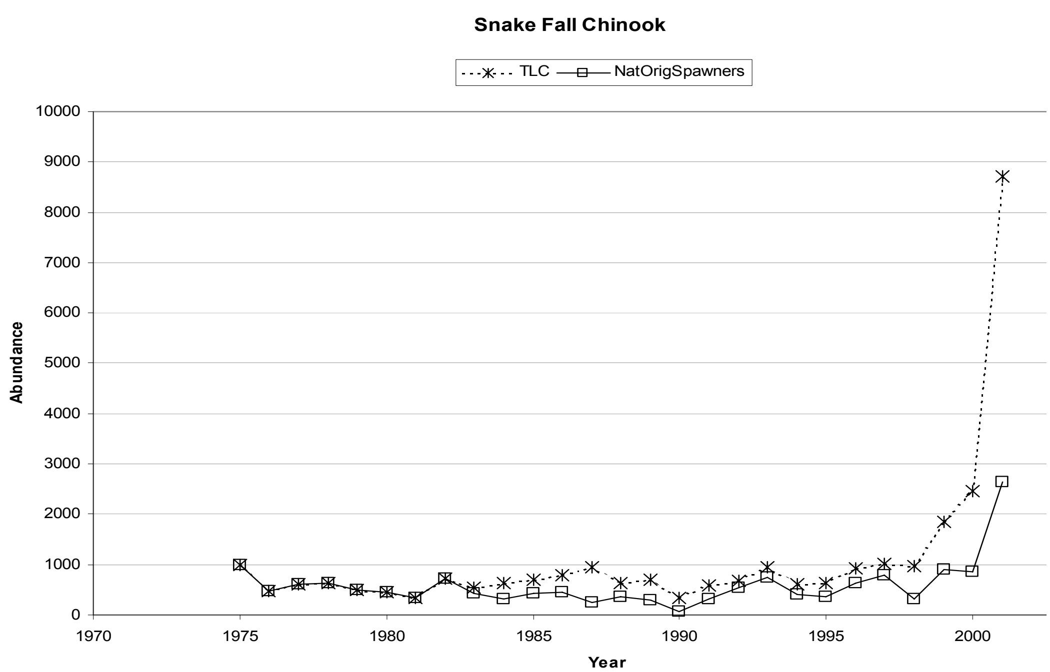


Figure A.2.1.1. Estimated spawning escapement of Lower Granite Dam.

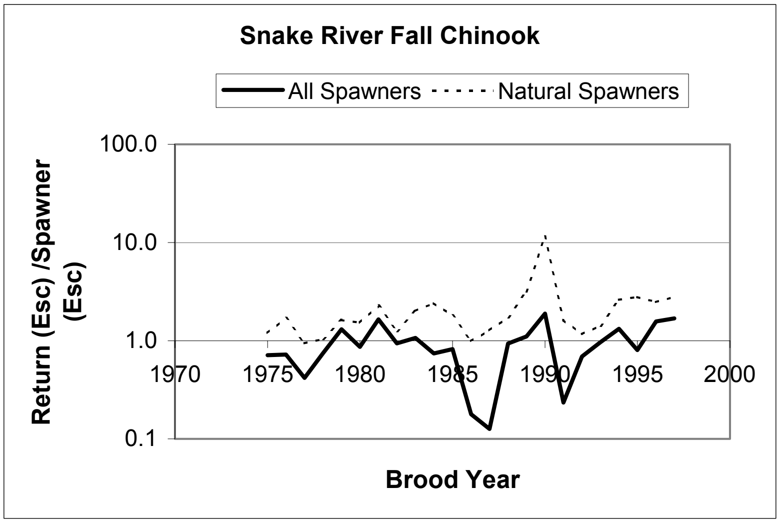


Figure A.2.1.2. Return/spawner escapements for Snake River fall-run chinook.

Productivity

Both the long-term and short-term trends in natural returns are positive (1.013, 1.188). The short-term (1990-2001) estimates of the median population growth rate λ are 0.98 with a hatchery spawning effectiveness of 1.0 (equivalent to that of wild spawners) and 1.137 with a hatchery spawning effectiveness of 0. The estimated long-term growth rate for the Snake River fall chinook population is strongly influenced by the hatchery effectiveness assumption. If hatchery spawners have been equally as effective as natural-origin spawners in contributing to brood year returns, the long-term λ estimate is 0.899 and the associated probability that λ is less than 1.0 is estimated as 98.7%. If hatchery returns over Lower Granite Dam are not contributing at all to natural production, the long-term estimate of λ is 1.024. The associated probability that λ is greater than 1.0 is 25.7%, under the assumption that hatchery effectiveness is 0.

Broodyear return-per-spawner (r/s) estimates were low for three or more consecutive years in the mid-1980s and the early 1990s (Figure A.2.1.2). The large increase in natural abundance in 2000 and 2001 is reflected in the 1996 and 1997 return-per-spawner estimates (1997 r/s based on 4-year-old component only).

Harvest impacts

Snake River fall chinook are subject to harvest in a wide range of fisheries due to their patterns of ocean distribution and the timing of their spawning run up the Columbia River. Coded-wire tag studies using Lyons Ferry Hatchery fish of Snake River origin indicate that Snake River fall chinook have a broad distribution. Recoveries of Snake River tagged fish have been reported from coastal fisheries from California, Oregon, Washington, British Columbia and Southeast Alaska. The timing of the return and upriver spawning migration of Snake River fall

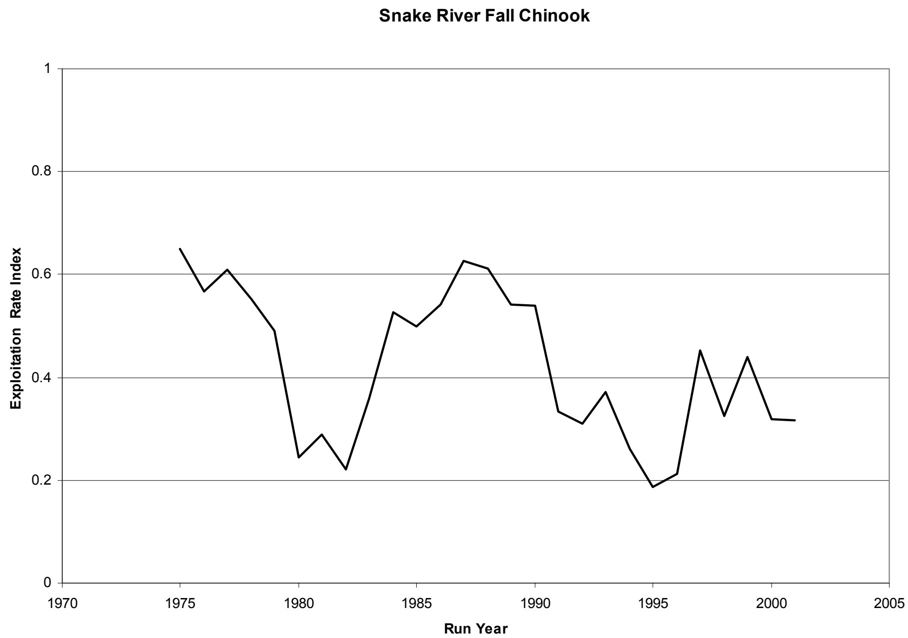


Figure A.2.1.3. Aggregate (ocean and in-river fisheries) exploitation rate index for Snake River fall chinook.

chinook overlaps with the Hanford Reach up-river bright returns as well as with several large hatchery runs returning to lower river release areas or to the major hatcheries adjacent to the lower mainstem Columbia River.

Harvest impacts on Snake River fall chinook declined after listing and have remained relatively constant in recent years (Figure A.2.1.3). The decline and subsequent listing of Snake River fall chinook prompted major restrictions on U. S. fisheries impacting this stock. In-river gillnet and sport fisheries are 'shaped' in time and space to maximize the catch of harvestable hatchery and natural (Hanford Reach) stocks while minimizing impacts on the intermingled Snake River fall chinook. Reductions in ocean fishery impacts on Snake River fall chinook resulted from management measures in ocean fisheries that were designed to protect weakened or declining stocks specific to each set of fisheries.

Mainstem hydropower impacts

Migration conditions for subyearling chinook migrants from the Snake River have generally improved since the early 1990s (FCRPS 2000 Biological Opinion). The lack of baseline data prior to the mid-1990s precludes quantifying the changes.

Habitat

There have been no major changes in available habitat for Snake River Fall chinook since the previous status review.

A.2.1.5 New Hatchery/ESU Information

Hatchery/natural composition

The composition of the run at Lower Granite is determined by sampling marked returns. Since the early 1980s, the run has consisted of three major components: unmarked returns of natural origin, marked returns from the Lyons Ferry Hatchery program, and strays from hatchery programs outside of the mainstem Snake River. While all three components of the run have increased in recent years, returns of Snake River origin have increased disproportionately to outside hatchery strays. Prior to the 1998/99 status reviews, the five-year average contribution of outside stocks to the escapement over Lower Granite Dam exceeded 26.2%. The most recent five-year average (1997-2001) was 12.4%, with the contribution in 2001 being just over 8%. The drop in relative contribution by outside stocks reflects the disproportionate increase in returns of the Lyons Ferry component, the systematic removal of marked hatchery fish at the Lower Granite trap, and modifications to the Umatilla program to increase homing of fall chinook release groups intended to return to the Umatilla River.

Categorizations of Snake River hatchery stocks (SSHAG 2003) can be found in Appendix A.5.1.

A.2.2 SNAKE RIVER SPRING/SUMMER CHINOOK

Spring and summer chinook salmon runs returning to the major tributaries of the Snake River were classified as an Evolutionarily Significant Unit (ESU) by NMFS (Matthews and Waples 1991). This ESU includes production areas that are characterized by spring-timed returns, summer-timed returns, and combinations from the two adult timing patterns. Runs classified as spring chinook are counted at Bonneville Dam beginning in early March and ending the first week of June; runs classified as summer chinook return to the Columbia River from June through August. Returning fish hold in deep mainstem and tributary pools until late summer, when they emigrate up into tributary areas and spawn. In general, spring type chinook tend to spawn in higher elevation reaches of major Snake River tributaries in mid- through late August, and summer run Snake River chinook spawn approximately 1 month later than spring-run fish.

Many of the Snake River tributaries used by spring and summer chinook runs exhibit two major features: extensive meanders through high elevation meadowlands and relatively steep lower sections joining the drainages to the mainstem Salmon (Matthews and Waples 1991). The combination of relatively high summer temperatures and the upland meadow habitat creates the potential for high juvenile salmonid productivity. Historically, the Salmon River system may have supported more than 40% of the total return of spring and summer chinook to the Columbia system (e.g., Fulton 1968)

The Snake River spring/summer chinook ESU includes current runs to the Tucannon River, the Grand Ronde River system, the Imnaha River and the Salmon River (Matthews and Waples 1991). The Salmon River system contains a range of habitats used by spring/summer chinook. The South Fork and Middle Fork tributaries to the Salmon currently support the bulk of natural production in the drainage. Two large tributaries entering above the confluence of the Middle Fork, the Lemhi and Pahimeroi Rivers, both drain broad alluvial valleys and are believed to have supported substantial, relatively productive anadromous fish runs. Returns into the upper Salmon River tributaries have re-established following the opening of passage around Sunbeam Dam on the mainstem Salmon River downstream of Stanley, ID. Sunbeam Dam was completed around 1910 as a power source for mining activities in the region. The dam was impassable to anadromous fish until the 1930s.

Current runs returning to the Clearwater River drainages were specifically not included in the Snake River spring/summer chinook ESU. Lewiston Dam in the lower mainstem of the Clearwater River was constructed in 1927 and functioned as an anadromous block until the early 1940s (Matthews and Waples 1991). Spring and summer chinook runs into the Clearwater system were reintroduced via hatchery outplants beginning in the late 1940s. As a result, Matthews and Waples (1991) concluded that "...the massive outplantings of nonindigenous stocks presumably substantially altered, if not eliminated, the original gene pool."

Spring and summer chinook from the Snake River basin exhibit stream type life history characteristics (Healey 1983). Eggs are deposited in late summer and early fall, incubate over the following winter and hatch in late winter/early spring of the following year. Juveniles rear through the summer, overwinter and migrate to sea in the spring of their second year of life. Depending on the tributary and the specific habitat conditions, juveniles may migrate extensively from natal reaches into alternative summer rearing and/or overwintering areas. Snake River spring/summer chinook return from the ocean to spawn primarily as 4 and 5 year old fish, after 2 to 3 years in the ocean. A small fraction of the fish return as 3-year-old ‘jacks’, heavily predominated by males.

A.2.2.1 Previous BRT Conclusions

The 1991 ESA status review (Mathews and Waples, 1991) of the Snake River spring/summer chinook ESU concluded that the ESU was at risk based on a set of key factors. Aggregate abundance of naturally produced Snake River spring/summer chinook runs had dropped to a small fraction of historical levels. Short-term projections (including jack counts, habitat/flow conditions in the brood years producing the next generation of returns) were for a continued downward trend in abundance. Risk modeling indicated that if the historical trend in abundance continued, the ESU as a whole was at risk of extinction within 100 years. The review identified related concerns at the population level within the ESU. Given the large number of potential production areas in the Snake basin and the low levels of annual abundance, risks to individual subpopulations may be greater than the extinction risk for the ESU as a whole. The 1998 chinook status review (Myers et al. 1998) summarized and updated these concerns. Both short and long-term abundance trends had continued downward. The report identified continuing disruption due to the impact of mainstem hydroelectric development including altered flow regimes and impacts on estuarine habitats. The 1998 review also identified regional habitat degradation and risks associated with the use of outside hatchery stocks in particular areas—specifically including major sections of the Grande Ronde River basin.

A.2.2.2 New Data and Analyses

Abundance

Direct estimates of annual runs of historical spring/summer chinook to the Snake River are not available. Chapman (1986) estimated that the Columbia River produced 2.5 million to 3.0 million spring and summer chinook per year in the late 1800s. Total spring and summer chinook production from the Snake Basin contributed a substantial proportion of those returns; the total annual production of Snake River spring and summer chinook may have been in excess of 1.5 million adult returns per year (Matthews and Waples 1991). Returns to Snake River tributaries had dropped to roughly 100,000 adults per year by the late 1960s (Fulton 1968). Increasing hatchery production contributed to subsequent years returns, masking a continued decline in natural production.

Aggregate returns of spring-run chinook (as measured at Lower Granite Dam) showed a large increase over recent year abundances (Figure A.2.2.1). The 1997-2001 geometric mean return of natural-origin chinook exceeded 3,700. The increase was largely driven by the 2001 return—estimated to have exceeded 17,000 naturally produced spring chinook—however, a large proportion of the run in 2001 was estimated to be of hatchery origin (98.4%). The summer run over Lower Granite Dam has increased as well (Figure A.2.2.2). The 1997-2001 geometric mean total return was slightly more than 6,000. The geometric mean return for the broodyears for the recent returns (1987-96) was 3,076 (Note: does not address hatchery/wild breakdowns of the aggregate run).

Returns in other production areas are shown in Figures A.2.2.3-A.2.2.16. The lowest five-year geometric mean returns for almost all of the individual Snake River spring/summer chinook production areas were in the 1990s. Sulphur Creek and Poverty Flats production areas had low five-year geometric mean returns in the early 1980s. Many, but not all, production areas had large increases in return year 2001.

Productivity

Long-term trend and long-term λ estimates were below 1 for all natural production data sets, reflecting the large declines since the 1960s. Short-term trends and λ estimates were generally positive with relatively large confidence intervals (Figure A.2.2.17). Grande Ronde and Imnaha data sets had the highest short-term growth rate estimates. Tucannon River, Poverty Flat (did not have 2000 and 2001 included) and Sulphur Creek index areas had the lowest short-term λ estimates in the series. Patterns in returns per spawners for stocks with complete age information (e.g. Minam River) show a series of extremely low return rates in the 1990s followed by increases in the 1995-97 brood years (Figure A.2.2.18).

Hydropower impacts

Snake River spring/summer chinook must migrate past a series of mainstem Snake and Columbia River hydroelectric dams on their migrations to and from the ocean. The Tucannon River population must migrate through six dams; all other major Snake River drainages supporting spring/summer chinook production are above eight dams. Earlier status reviews concluded that mainstem Columbia and Snake River hydroelectric projects have resulted in a major disruption of migration corridors and affected flow regimes and estuarine habitat.

Harvest

Harvest impacts on Snake River spring chinook are generally low. Ocean harvest rates are also low. Historical harvest estimates reflect the impact of mainstem and tributary in-river fisheries. In response to initial declines in returns, in-river harvests of both spring and summer chinook were restricted beginning in the early 1970s. Fishery impacts were further reduced following listing in 1991, with lower harvest rates from 1991-1999. In response to the large increase in returns of spring chinook runs, additional impacts were allowed beginning in 2000. The management agreement providing for increased impacts as a function of abundance also calls for additional reductions if and when runs drop back down below prescribed thresholds.

Habitat

Tributary habitat conditions vary widely among the various drainages of the Snake River basin. There is habitat degradation in many areas of the basin reflecting the impacts of forest, grazing and mining practices. Impacts relative to anadromous fish include lack of pools, increased water temperatures, low flows, poor overwintering conditions, and high sediment loads. Substantial portions of the Salmon River drainage, particularly in the Middle Fork, are protected in wilderness areas.

A.2.2.5 New Hatchery/ESU Information

Hatchery production

Spring and summer chinook are produced from a number of artificial production facilities in the Snake River Basin. Much of the production was initiated under the Lower Snake River Compensation Plan. Lyons Ferry Hatchery serves as a rearing station for Tucannon spring chinook broodstock. Rapid River Hatchery and McCall Hatchery provide rearing support for a regionally derived summer chinook broodstock released into lower Salmon River areas. Two major hatchery programs have operated in the upper Salmon basin—the Pahsimeroi and Sawtooth facilities. Since the mid-1990s, small-scale natural stock supplementation studies and captive breeding efforts have been initiated in the Snake River basin.

Historically, releases from broodstock originating outside of the basin have constituted a relatively small fraction of the total release into the basin. The 1998 chinook status review (Myers et al. 1998) identified concerns regarding the use of the Rapid River Hatchery stock reared at Lookingglass Hatchery in the Grande Ronde basin. The Rapid River stock was originally developed from broodstock collected from the spring chinook returns to historical production areas above the Hells Canyon complex.

Use of the Rapid River stock in Grande Ronde drainage hatchery programs has been actively phased out since the early 1990s. In addition, a substantial proportion of marked returns of Rapid River stock released in the Grande Ronde have been intercepted and removed at the Lower Granite Dam ladder and at some tributary level weirs. Carcass survey data indicate significant declines in hatchery contributions to natural spawning in areas previously subject to Rapid River stock strays.

Concerns for the high incidence of BKD disease in Snake Basin hatchery facilities were also identified (Myers et al. 1998).

Categorization for Snake River spring/summer chinook hatchery stocks (SSHAG 2003) can be found in Appendix A.5.1.

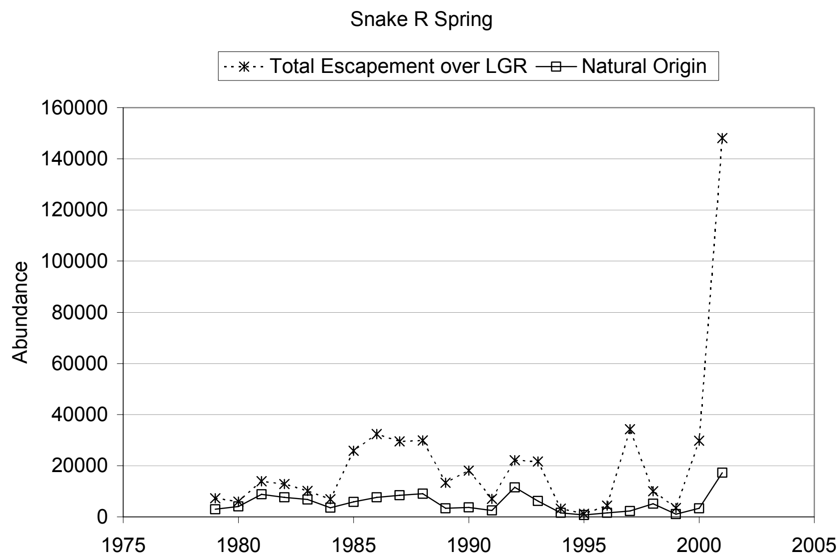


Figure A.2.2.1. Snake River spring chinook spawning escapement.

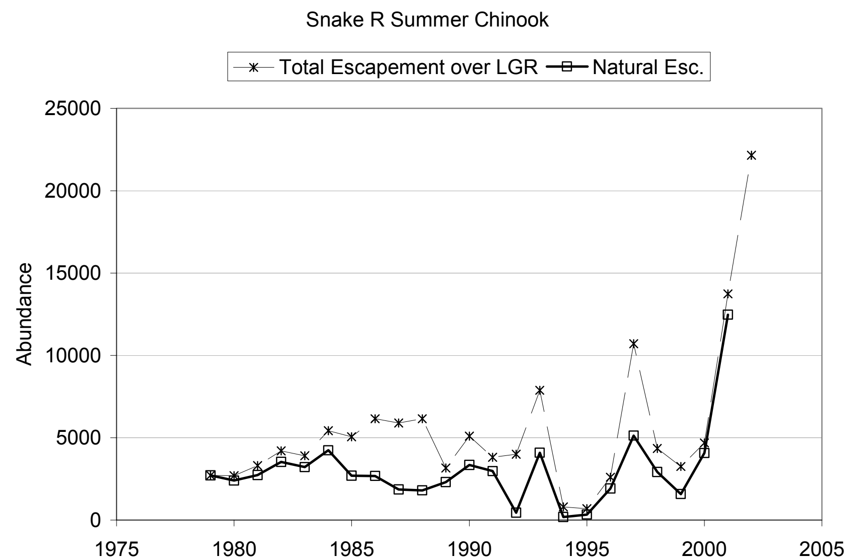


Figure A.2.2.2. Snake River summer chinook spawning escapement.

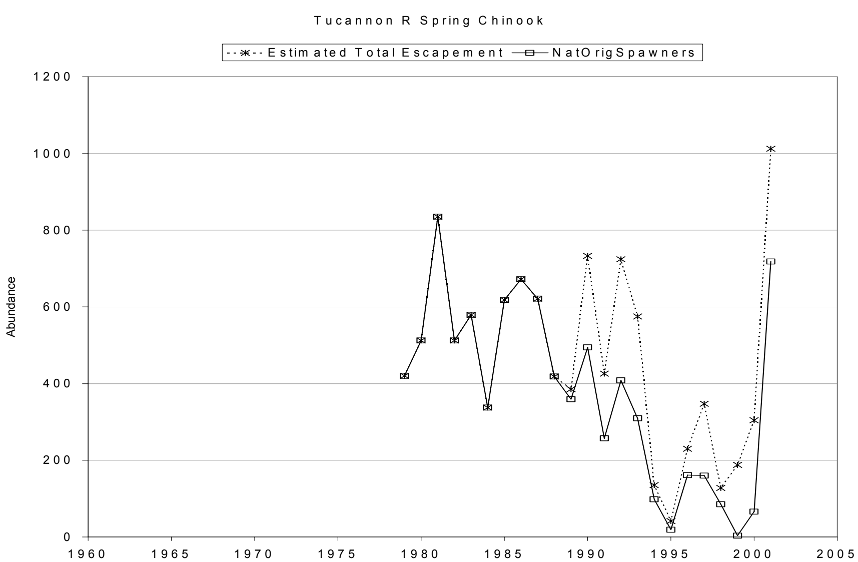


Figure A.2.2.3. Tucannon River spring chinook spawning escapement.

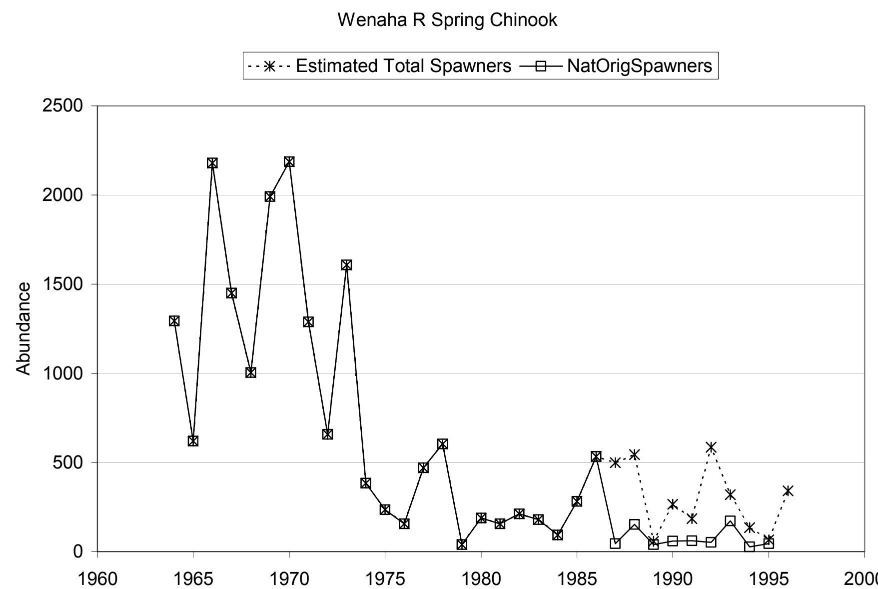


Figure A.2.2.4. Wenaha River spring chinook spawning escapement.

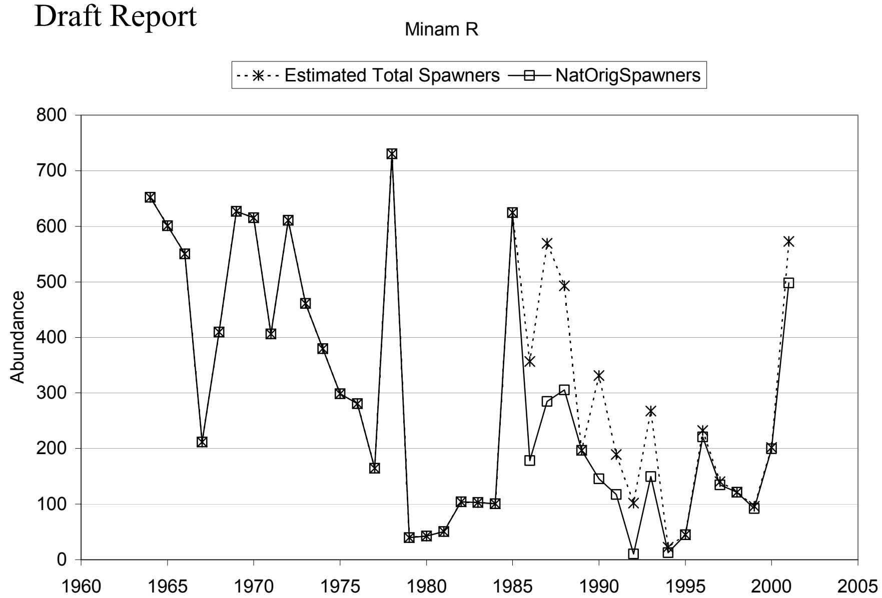


Figure A.2.2.5. Minam River chinook spawning escapements.

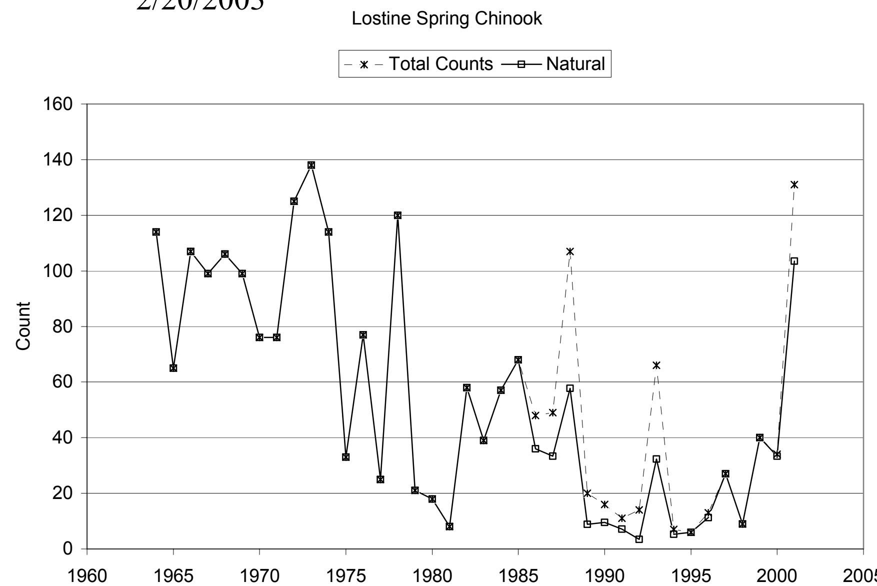


Figure A.2.2.6. Lostine River spring chinook total counts.

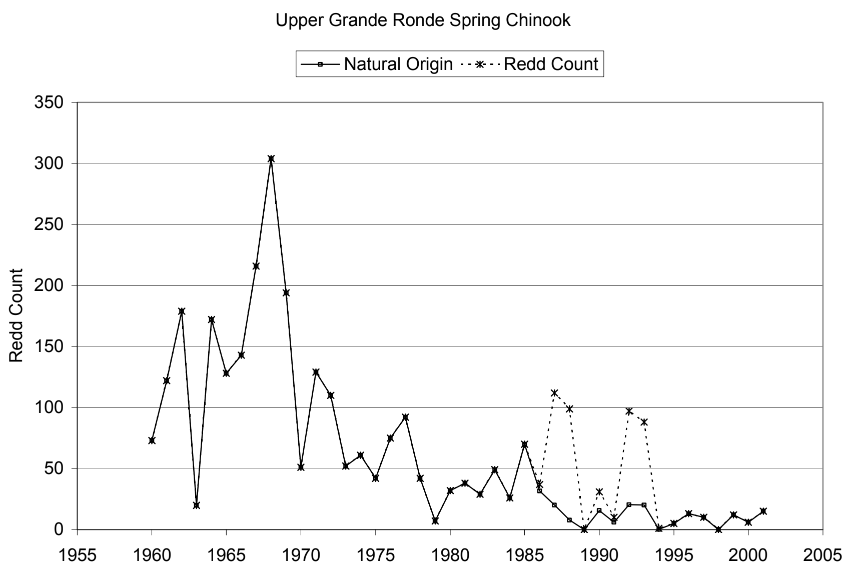


Figure A.2.2.7. Upper Grande Ronde River spring chinook redd counts.

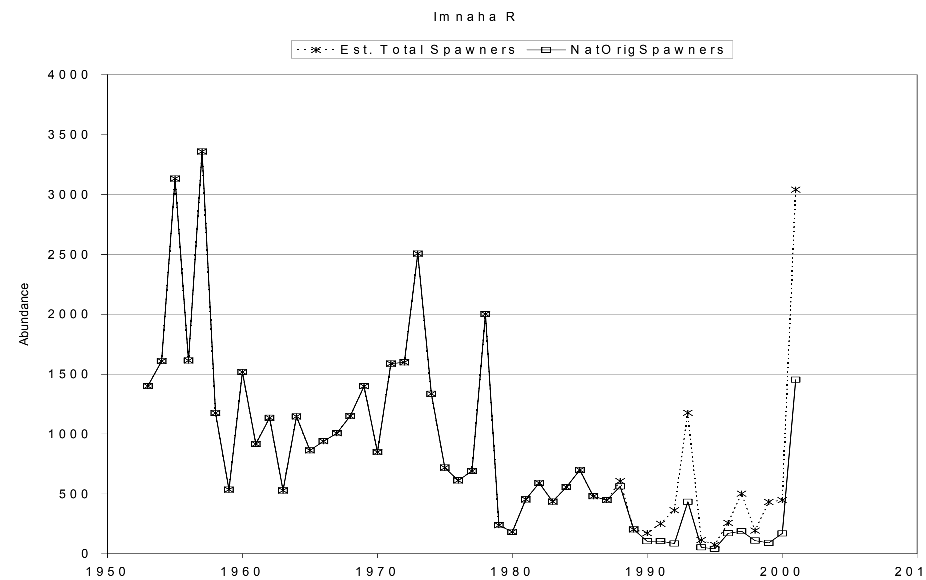


Figure A.2.2.8. Imnaha River chinook spawning escapement.

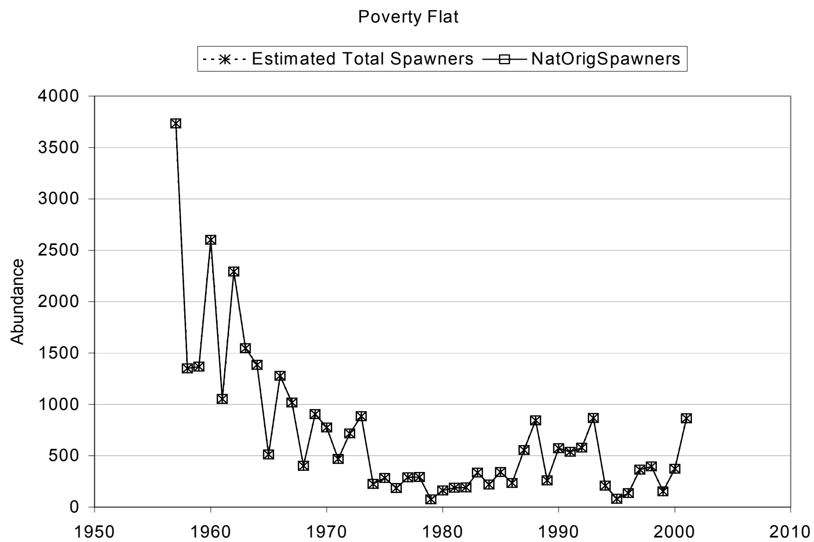


Figure A.2.2.9. Poverty Flat chinook spawning escapement.

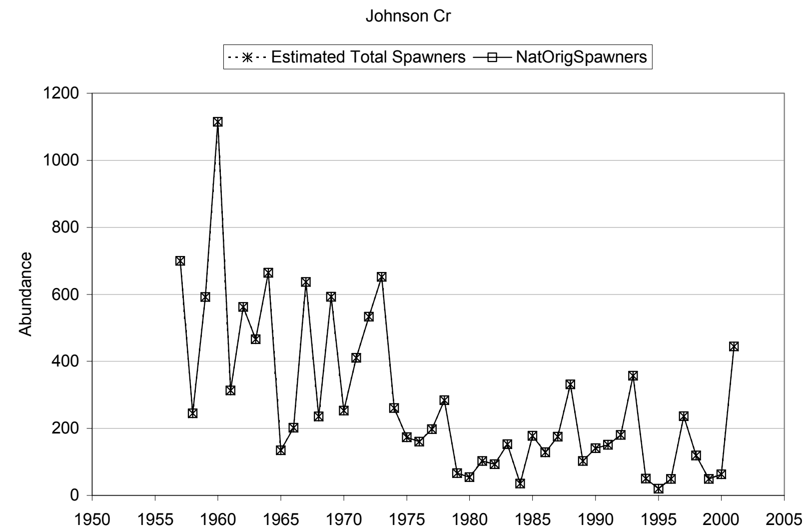


Figure A.2.2.10. Johnson Creek chinook spawning escapement.

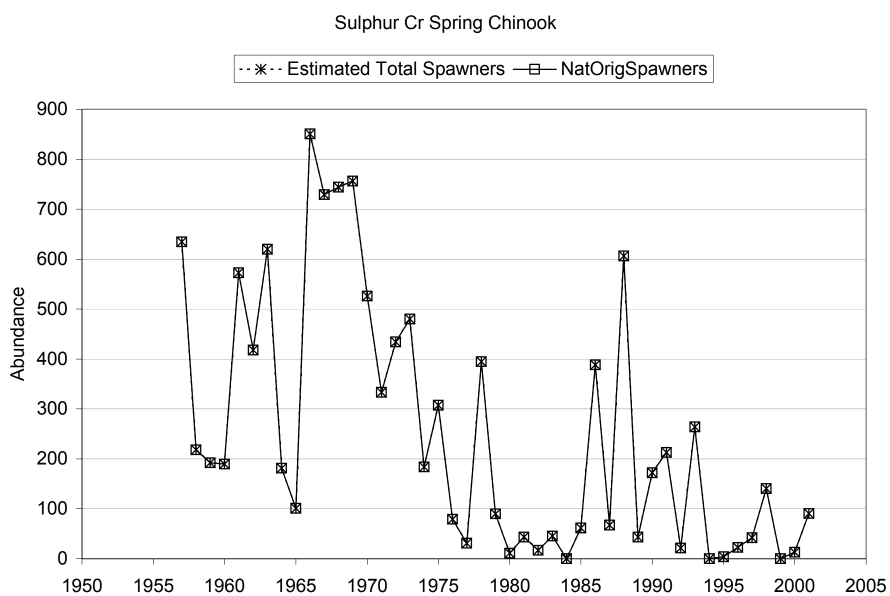


Figure A.2.2.11. Sulphur Creek spring chinook spawning escapement.

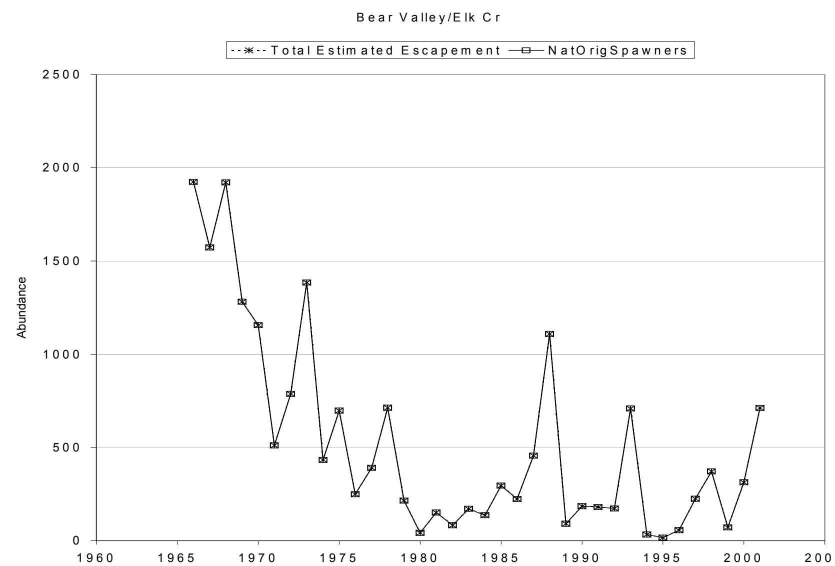


Figure A.2.2.12. Bear Valley/Elk Creek chinook spawning escapement.

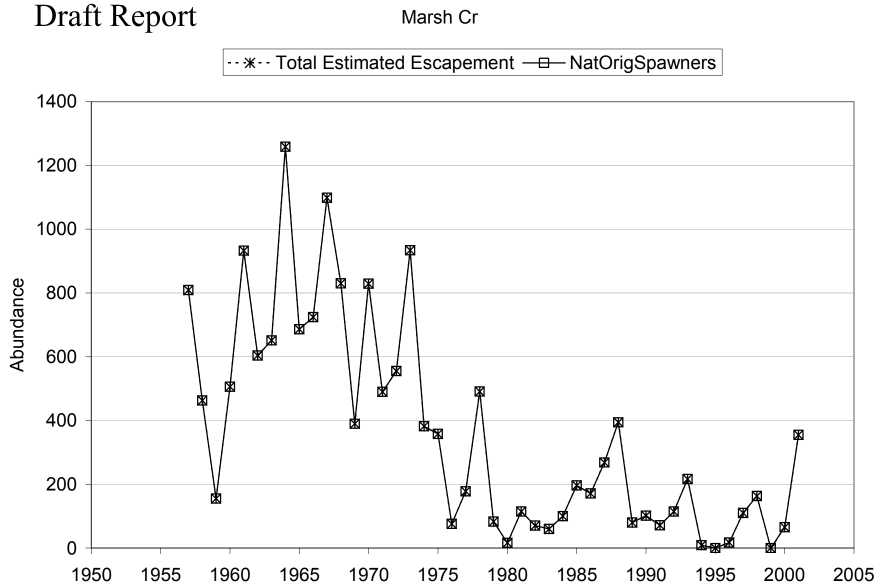


Figure A.2.2.13. Marsh Creek chinook spawning escapement.

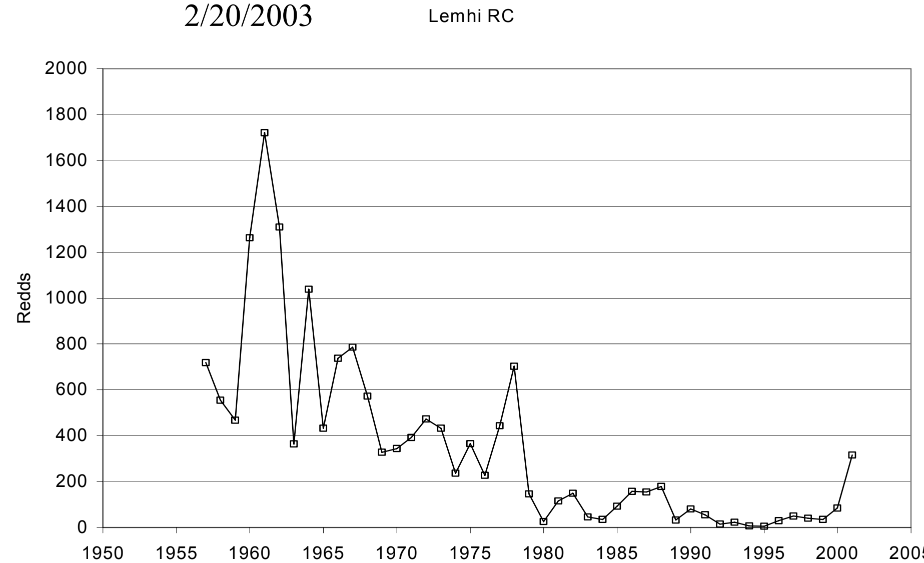


Figure A.2.2.14. Lemhi redd counts.

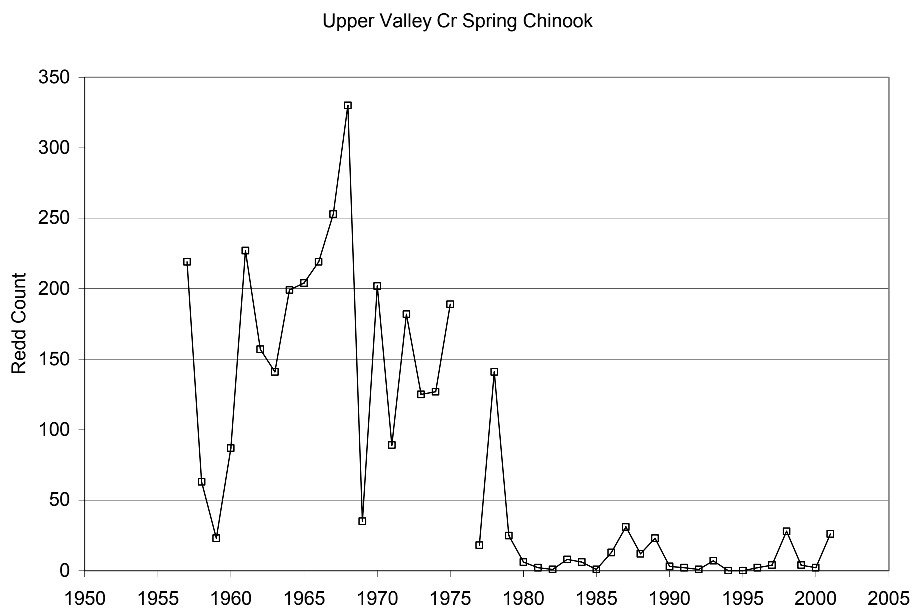


Figure A.2.2.15. Upper Vallry Creek spring chinook redd counts.

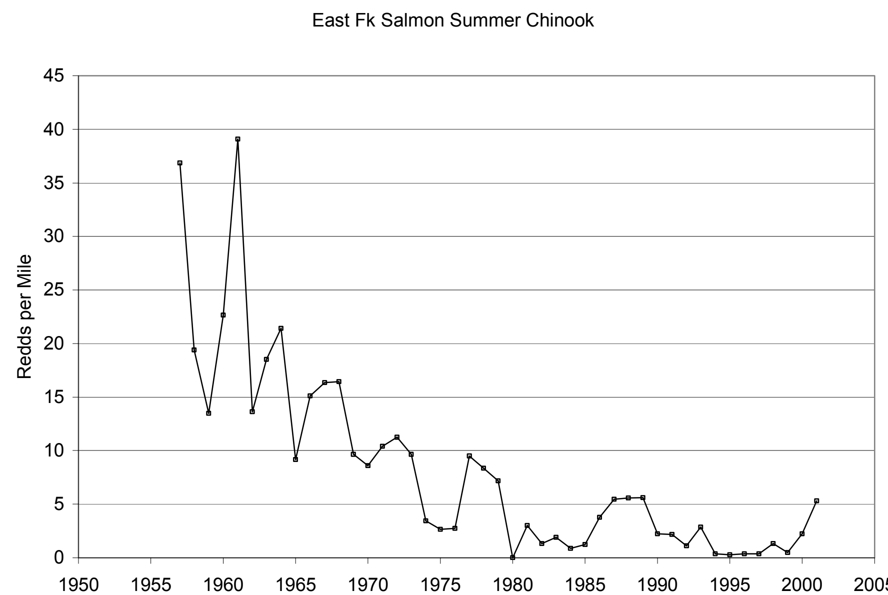
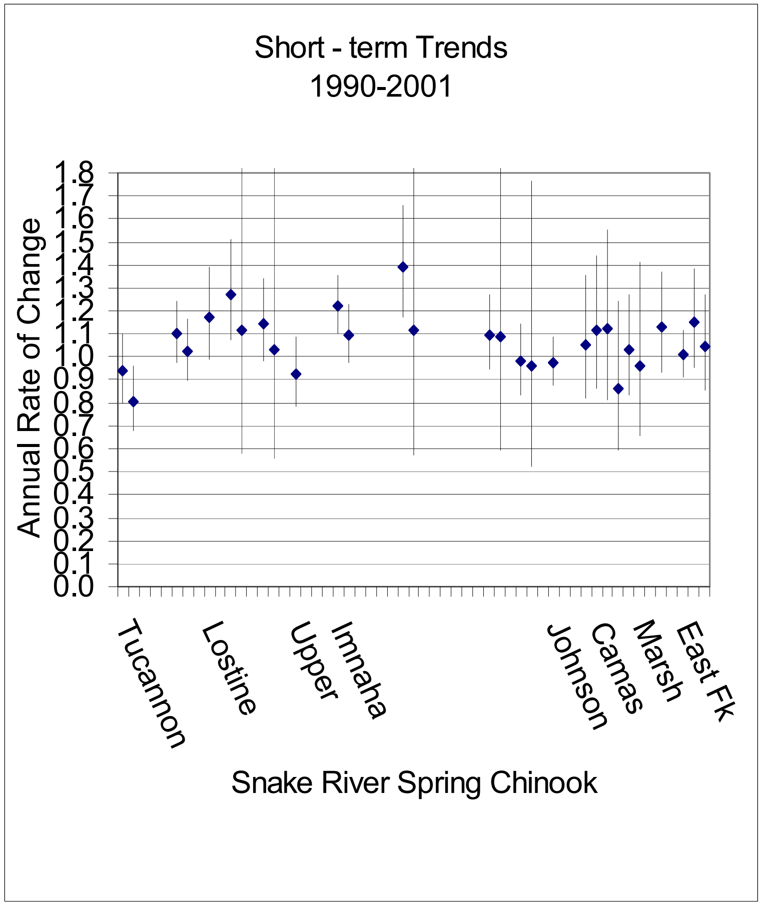


Figure A.2.2.16. East Fork Salmon summer chinook redds/mile.



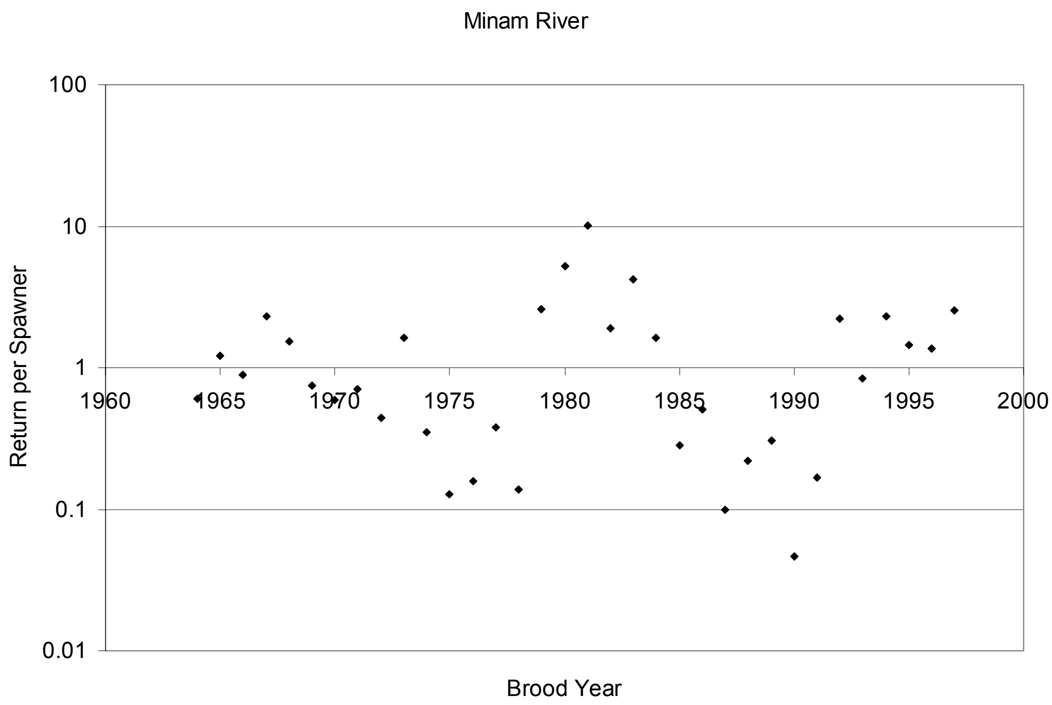


Figure A.2.2.19. Snake River spring/summer chinook returns/spawner

Figure A.2.2.18. Short-term trends of Snake River spring/summer production areas.

A.2.3 UPPER COLUMBIA RIVER SPRING-RUN CHINOOK

There are no estimates of historical abundance specific to this ESU prior to the 1930s. The drainages supporting this ESU are all above Rock Island Dam on the upper Columbia River. Rock Island Dam is the oldest major hydroelectric project on the Columbia River; it began operations in 1933. Counts of returning chinook have been made since the 1930s. Annual estimates of the aggregate return of spring chinook to the upper Columbia are derived from the dam counts based on the nadir between spring and summer return peaks. Spring chinook salmon currently spawn in three major drainages above Rock Island Dam--Wenatchee, Methow and Entiat Rivers. Historically, spring chinook may have also used portions of the Okanogan River.

Grand Coulee Dam, completed in 1938, formed an impassable block to the upstream migration of anadromous fish. Chief Joseph Dam was constructed on the mainstem Columbia River downstream from Grand Coulee Dam and is also an anadromous block. There are no specific estimates of historical production of spring chinook from mainstem tributaries above Grand Coulee Dam. Habitat typical of that used by spring chinook salmon in accessible portions of the Columbia basin is found in the middle/upper reaches of mainstem tributaries above Grand Coulee Dam. It is likely that the historical range of this ESU included these areas.

Artificial production efforts in the area occupied by the Upper Columbia spring chinook ESU extend back to the 1890s. Hatchery efforts were initiated in the Wenatchee and Methow systems to augment catches in response to declining natural production (e.g., Craig and Soumela 1941). While there are no direct estimates of adult production from early efforts, it is likely contributions were small.

In the late 1930s, the Grand Coulee Fish Maintenance Program (GCFMP) was initiated to address the fact that the completion of the Grand Coulee dam cut off anadromous access above site of the dam. Returning salmonids, including spring chinook, were trapped at Rock Island Dam and either transplanted as adults or released as juveniles into selected production areas within the accessible drainages below Grand Coulee Dam. Nason Creek in the Wenatchee system was a primary adult transplantation area in this effort. The program was conducted annually from 1938 until the mid-1940s.

A.2.3.1 Previous BRT Conclusions

Previous BRT Review

The Upper Columbia spring chinook ESU was reviewed by the BRT in late 1998 (BRT 1998b). "The BRT was mostly concerned about risks falling under the abundance/distribution and trends/productivity risk categories for the ESU...average recent escapements to the ESU has been less than 5,000 hatchery plus wild chinook salmon, and individual populations all consist of less than 100 fish. The BRT was concerned that at these population sizes, negative effects of demographic and genetic stochastic processes are likely to occur. Furthermore, both long- and short-term trends in abundance are declining, many strongly so." The BRT noted that the implemetation of emergency natural broodstocking and captive broodstocking efforts for the ESU "...indicate(s) the severity of the population declines to critically small sizes." The BRT recognized that "(h)abitat degradation, blockages and hydrosystem passage mortality all have contributed to the significant declines in this ESU."

A.2.3.2 New Data and Updated Analyses

WDFW, the Yakima Tribe and the Fish and Wildlife Service conduct annual redd count surveys in nine selected production areas within the geographical area encompassed by this ESU (Mosey and Murphy 2002, Hubble and Crampton 2000, Carie 2000). Prior to 1987, redd count estimates were single-survey peak counts. From 1987 on, annual redd counts are generated from a series of on-the-ground counts and represent the total number of redds constructed in any particular year. The agencies use annual dam counts from the mainstem Mid-Columbia dams as the basis for expanding redd counts to estimates of total spring chinook returns. Returns to hatchery facilities are subtracted from the dam counts prior to the expansion. Updated returns are summarized in Table A.2.3.1 and in Figures (A.2.3.1-A.2.3.6).

An initial set of population definitions for Upper Columbia spring chinook ESU along with basic criteria for evaluating the status of each population were developed using the Viable Salmonid Population (VSP) guidelines described in McElhany et al. (2000). The definitions and criteria are described in Ford et al. (2000) and have been used in the development and review of Mid-Columbia PUD plans and the FCRPS Biological Opinion. The interim definitions and criteria are being reviewed as recommendations by the Interior Columbia Technical Recovery Team. Briefly, the joint technical team recommended that the Wenatchee River, the Entiat River and the Methow River be considered as separate populations within the Upper Columbia Steelhead ESU. The historical status of spring chinook production in the Okanogan River is uncertain. The committee deferred a decision on the Okanogan to the Technical Recovery Team. Abundance, productivity and spatial structure criteria for each of the populations in the ESU were developed and are described in Ford et al. (2001).

A.2.3.3 New Hatchery/ESU Information

Three national fish hatcheries operated by the U. S. Fish and Wildlife Service are located within the geographic area associated with this ESU. These hatchery programs were established as mitigation programs. Leavenworth National Fish Hatchery, located on Icicle Creek in the Wenatchee River system, has released chinook salmon since 1940. Entiat National Fish Hatchery is located on the Entiat River, approximately 10 km upstream of the confluence with the Columbia River mainstem. Spring chinook have been released from this facility since 1974. Winthrop National Fish Hatchery is on the Methow River mainstem, approximately 72 km upstream of the confluence with the Columbia River. Spring chinook were released from 1941-1961, and from 1974 to the present. Initial spring chinook releases from these facilities were for the GCFMP project. Leavenworth Hatchery returns served as the principle stock source for all three facilities until recently. Production was augmented with eggs transferred into the programs from facilities outside of the ESU, primarily Carson Hatchery. Broodstocking for each hatchery program has been switched to emphasize locally adapted broodstocks. Carcass surveys and broodstocking efforts in the upstream natural spawning areas of the Wenatchee River and the Entiat River support the assumption that the stray rate from the downstream hatchery facilities is low—on the order of 1%-5%. Significantly higher contribution rates have been observed in mainstem Methow natural spawning areas, possibly due to the close proximity of the hatchery.

Additional spring chinook hatchery production efforts were initiated in the 1980s as mitigation for smolt losses at the five mainstem mid-Columbia River projects operated by public utility districts. This program is aimed at directly supplementing targeted natural production areas in the Wenatchee and Methow River systems. In the Wenatchee River drainage, this program has targeted the Chiwawa River production area. Broodstock are collected at a weir located just upstream of the mouth of the Chiwawa River. Release groups are returned to this site for final acclimation and release. In the Methow River, the program is operated in conjunction with Winthrop Hatchery. Juveniles are reared at the Winthrop Facility and moved to acclimation sites on the Twisp, Chewuch, and Methow mainstem shortly before the spring migration period. The Methow program was initiated with Winthrop Hatchery stock and is being converted to local broodstock. These supplementation programs have had two major impacts on natural production areas. Returns to natural spawning areas have included increasing numbers of supplementation fish in recent years, especially in the Methow mainstem spawning areas adjacent to the hatchery. In addition, following the major drop in returns in the mid-1990s, a major portion of the natural return was taken as broodstock for supplementation. In 2 years (1995 and 1997) virtually the entire adult run to Wells Dam were taken.

The WDFW SASSI report identified nine stocks of spring chinook within the upper Columbia spring chinook ESU. Ford et al. (2001) describes the results of applying the population definition and criteria provided in McElhany et al. (2000) to current upper Columbia spring chinook production. The conclusions of the effort were that "...there are (or historically were) three or four independent viable populations of spring chinook salmon in the upper Columbia River basin, inhabiting the Wenatchee, Entiat, Methow and (possibly) the Okanogan River basins. There appears to be considerable population substructure within the Wenatchee and Methow basins, however, this substructure should be considered when evaluating recovery goals and management actions."[2]

Hatchery impacts

Hatchery impacts vary among the production areas. Large on-station production programs in the Wenatchee and Entiat River drainages are located in the lower reaches, some distance downstream of natural spawning areas. In the Methow River, Winthrop National Fish Hatchery is located upstream, adjacent to a portion of the mainstem spawning reach for spring chinook and steelhead. Straying of returning hatchery origin adults into the natural production areas is thought to be low for the Wenatchee River and Entiat River. In years when the return of naturally produced adults is extremely low, the proportion of hatchery adults on the spawning grounds can be high, even if the dispersal rate of the returning hatchery fish is low. It is likely that returning hatchery fish contribute to spawning in natural production areas in the Methow at a higher rate. Carcass sampling data are available for a limited number of year/area combinations for the upper Columbia drainages (e.g., WDF 1992).

[2]Spring chinook spawning in Icicle Creek and the Leavenworth Hatchery are considered an independent, hatchery-derived population that is not part of the ESU (NMFS 1999).

Spring chinook returns to the Wenatchee and the Methow River systems have included relatively large numbers of supplementation program fish in recent years. The total return to natural spawning areas in the Wenatchee River system for 2001 is estimated to be approximately 4,000-1,200 returning from natural spawning and 2,800 from the hatchery-based supplementation program. The return to spawning areas for the Methow in 2001 is estimated at well over 9,000. Carcass surveys indicate that returning supplementation adults accounted for approximately 80% of the 2001 run to the Methow spawning areas. Supplemenation programs have contributed substantially to getting fish on the spawning grounds in recent years. Little information is available to assess the long-term impact of high levels of supplementation on productivity. Categorization for Upper Columbia River spring chinook hatchery stocks (SSHAG 2003) can be found in Appendix A.5.1.

A.2.3.4 Comparison with Previous Data

All three of the existing upper Columbia River spring chinook populations have exhibited similar trends and patterns in abundance over the past 40 years. The 1998 Chinook Status Review (Myers et al. 1998) reported that long-term trends in abundance for upper Columbia spring chinook populations were generally negative, ranging from -5% to +1%. Analyses of the data series, updated to include 1996-2001 returns, indicate that those trends have continued. The long-term trend in spawning escapement is downward for all three systems. The Wenatchee River spawning escapements have declined an average of 5.6% per year, the Entiat River population at an average of 4.8%, and the Methow River population an average rate of 6.3% per year since 1958. These rates of decline were calculated from the redd count data series[3].

Mainstem spring chinook fisheries harvested chinook at rates between 30%-40% per year through the early1970s. Harvest was substantially reduced by restricting mainstem commercial fisheries and sport harvest in the mid-1970s. The calculated downward trend in abundance for the upper Columbia stocks would be higher if the early redd counts had been revised to reflect the potential ‘transfer’ from harvest to escapement for the early years in the series.

In the 1960s and 1970s, spawning escapement estimates were relatively high with substantial year-to-year variability. Escapements declined in the early 1980s, then peaked at relatively high levels in the mid 1980s. Returns declined sharply in the late 1980s and early 1990s. Returns between 1990-94 were at the lowest levels observed in the 40-plus years of the data sets. The Upper Columbia Biological Requirements Workgroup (Ford et al. 2001) recommended interim delisting levels of 3,750, 500, and 2,200 spawners for the populations returning to the Wenatchee, Entiat, and Methow drainages, respectively. The most recent 5-year geometric mean spawning escapements (1997-2001) were at 8%-15% of these levels. Target levels have not been exceeded since 1985 for the Methow run and the early 1970s for the Wenatchee and Entiat populations.

[3]Prior to 1987, annual redd counts were obtained from single surveys and reported as peak counts. From 1987 on, redd counts were derived from multiple surveys and are reported as annual total counts. An adjustment factor of 1.7 was used to expand the pre-1987 redd counts for comparison with the more recent total counts. (Beamsesderfer et al. 1997).

Short-term rates for the aggregate population areas reported in the 1998 Status Review (Myers et al. 1998) ranged from a -15.3% (Methow R.) to a -37.4% (Wenatchee R.). The Escapements from 1996-1999 reflected that downward trend. Escapements increased substantially in 2000 and 2001 in all three systems. Returns to the Methow River and the Wenatchee River reflected the higher return rate on natural production as well as a large increase in contributions from supplementation programs. Short-term trends (1990-2001) in natural returns remain negative for all three upper Columbia spring chinook populations. Natural returns to the spawning grounds for the Entiat, Methow, and Wenatchee River populations continued downward at average rates of 3%, 10%, and 16% respectively.

Short- and long-term trends in natural returns to the individual subpopulations within the Wenatchee and Methow systems were consistent with the aggregate population level trends. Long-term and short-term trends for Upper Columbia spring chinook populations are shown in Figures A.2.3.7-A.2.3.8.

McClure et al. (in press) reported standardized quantitative risk assessment results for 152 listed salmon stocks in the Columbia basin, including representative data sets (1980-2000 return years) for upper Columbia spring chinook. Average annual growth rate (λ) for the upper spring chinook population was estimated as 0.85, the lowest average reported for any of the Columbia River ESUs analyzed in the study. Assuming that population growth rates were to continue at the 1980-2000 levels, upper Columbia spring chinook populations are projected to have a very high probability of a 90% decline within 50 years (0.87 for the Methow River population, 1.0 for the Wenatchee and Entiat runs).

The major harvest impacts on upper Columbia River spring chinook have been in mainstem fisheries below McNary Dam and in sport fisheries in each tributary. There are no specific estimates of historical harvest impacts on upper Columbia spring chinook runs. Assuming that upper Columbia spring chinook runs were equally available to mainstem commercial fisheries as were the runs to other areas of the Snake and Columbia rivers, harvest rates in the lower river commercial fisheries were likely on the order of 20%-40% of the in-river run. Lower river harvest rates on up-river spring chinook stocks were sharply curtailed beginning in 1980 and were again reduced after the listing of Snake River spring/summer chinook in the early 1990s. Sport fishery impacts were also curtailed. Harvest impacts are currently being managed under a harvest management schedule—harvest rates are curtailed even further if the average return drops below a predefined level, increases area allowed at high run sizes.

Mainstem hydropower impacts

Upper Columbia spring chinook runs are subject to passage mortalities associated with mainstem hydroelectric projects. Production from all of these drainages passes through the four lower river federal projects and a varying number of Mid-Columbia River Public Utility District projects. The Wenatchee River enters the Columbia River above seven mainstem dams, the Entiat above eight dams; the Methow River and Okanogan Rivers above nine dams. Since the Early 1990s, the draft Mid-Columbia Habitat Conservation Plan establishes salmonid survival objectives for Wells, Rocky Reach, and Rock Island dams. Interim operating guidelines apply to Wanapum and Priest Rapids dam. Operational improvements have been made to increase outmigrant survival through the mainstem Mid-Columbia Public Utility hydroelectric dams (Cooney 2001, FCRPS Biological Opinion 2000).

Each of the upper Columbia River spring chinook areas has a particular set of habitat problems. In general, tributary habitat problems affecting this ESU include the effects of increasing urbanization on the lower reaches, irrigation/flow diversions in up-river sections of the major drainage, and the impacts of grazing on middle reaches.

Previous assessments of stocks within this ESU have identified several as being at risk or of concern. WDF et al. (1993) considered nine stocks within this ESU, of which eight were considered to be of native origin and predominately natural production. The status of all nine stocks was considered as depressed.

Nehlsen et al. (1991) listed six additional stocks from the upper Columbia as extinct. All of those stocks were associated with drainages entering the Columbia River mainstem above Chief Joseph and Grand Coulee Dams. Those projects blocked off access by adult anadromous fish to the upper basin.

Table A.2.3.1. Summary of recent population status information.

Production Area	5 Year Geometric Mean		Long-Term Trend		Short-Term Trend	
	1989-95	1990-2001	1998 Assessment	1960-2001	1998 Assessment	1990-2001
Methow River	**355**	**282**		**-5.4**		**-9.7**
Methow Mainstem			1.1	-5.9	-15.3	-5.5
Twisp			-4.1	-7.7	-2.1	-12.1
Chewuch			-2.1	-7.2	-22.5	-9.0
Lost/Early Winters			-2.2	-6.8	-16.1	-14.1
Entiat River	**89**	**65**	**-18.5**	**-5.7**	**-19.4**	**-6.2**
Wenatchee River	**328**	**273**	**-11.5**	**-6.9**	**-37.4**	**-7.4**
Chiwawa			-3.1	-5.3	-35.1	-8.4
Nason Cr.			-4.1	-6.2	-20.9	-6.8
Upper Wenatchee			-2.1	-5.3	-36.6	-11.7
White			0.9	-3	-25.0	-8.0
Little Wenatchee			-0.7	-4.6	-26.5	-16.5

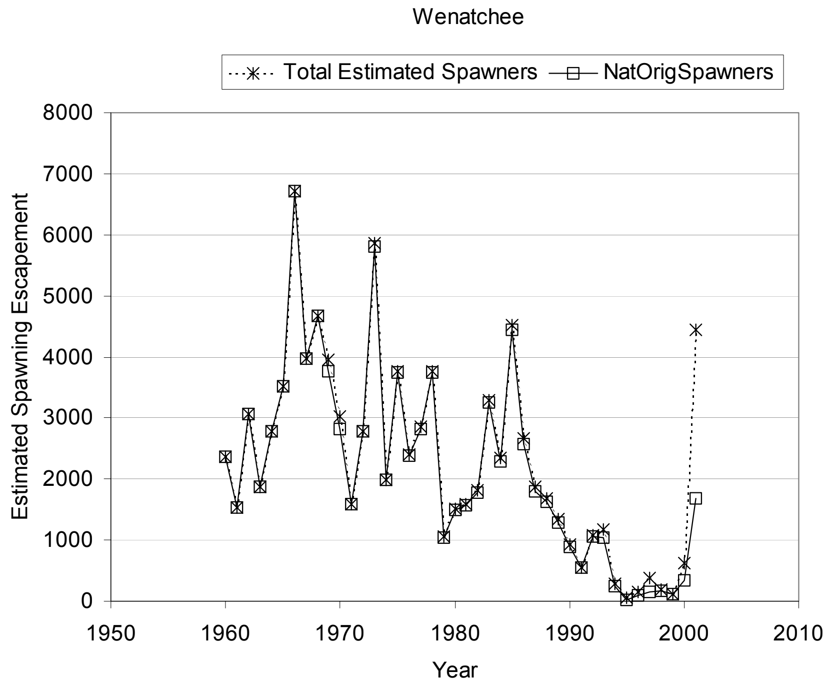


Figure A.2.3.1. Wenatchee Spring chinook: Estimated spawning escapement. Expanded from redd counts (Beamesderfer et al. 1997, Cooney 2001). Recent year data from Mosey & Murphy (2002).

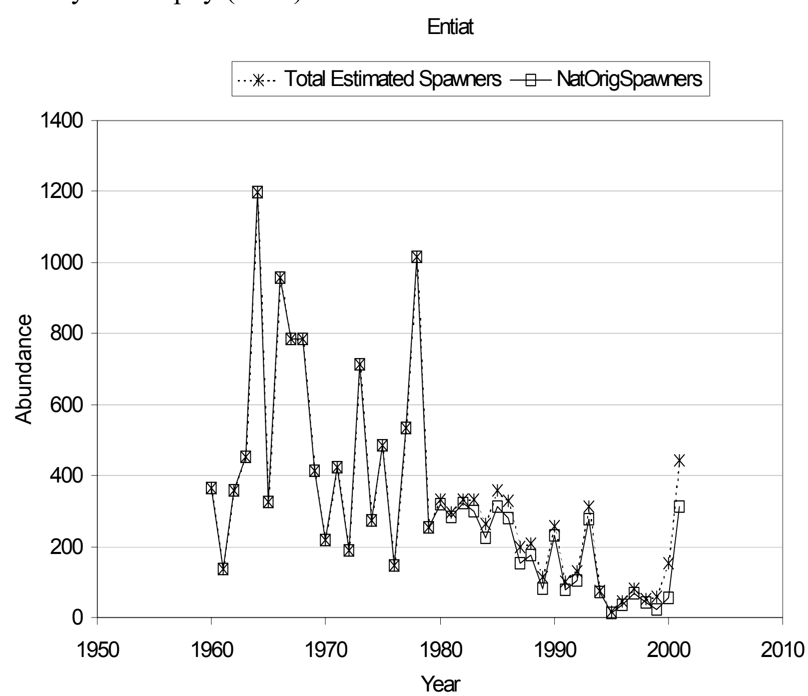


Figure A.2.3.2. Entiat Spring chinook: Estimated spawning escapement. Expanded from redd counts (Beamesderfer et al. 1997, Cooney 2001). Recent-year data from Carie (2002).

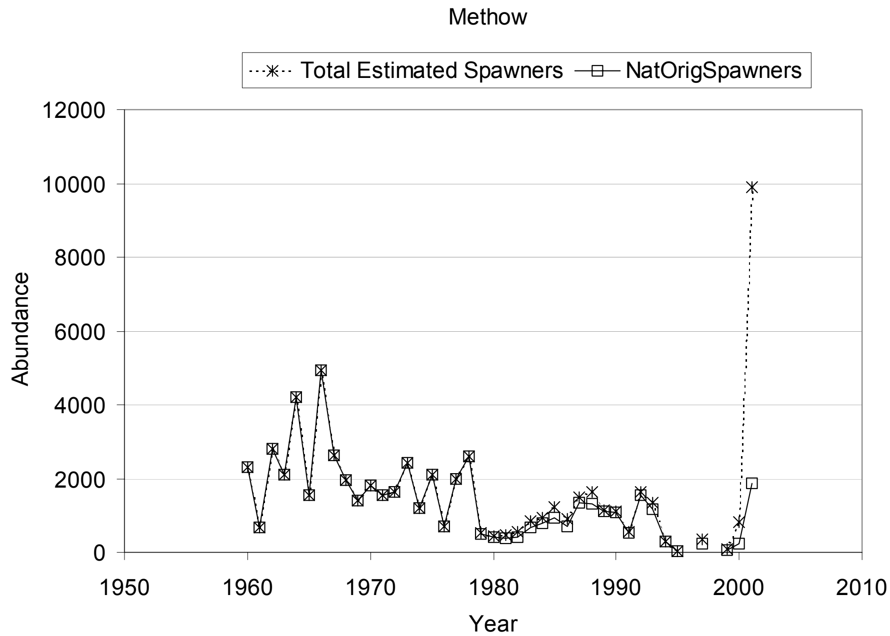


Figure A.2.3.3. Methow Spring chinook: Estimated spawning escapement. Expanded from redd counts (Beamesderfer et al. 1997, Cooney 2001). Recent year data from Yakima Indian Nation Fisheries (J. Hubbell, pers. comm.).

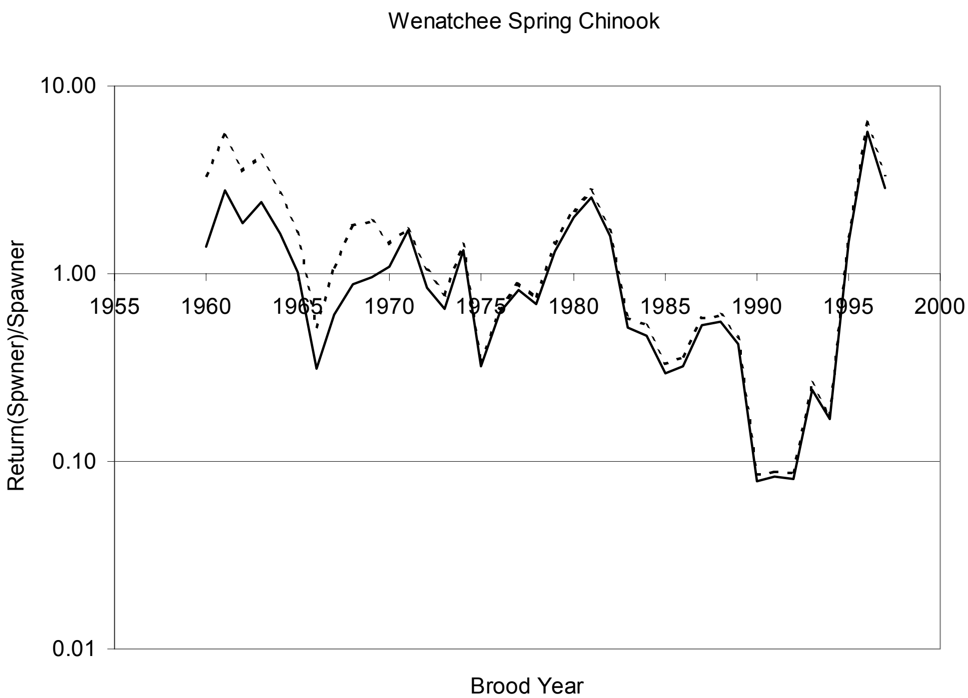


Figure A.2.3.4. Wenatchee Spring chinook Return per spawner by brood year (returns to spawning grounds).

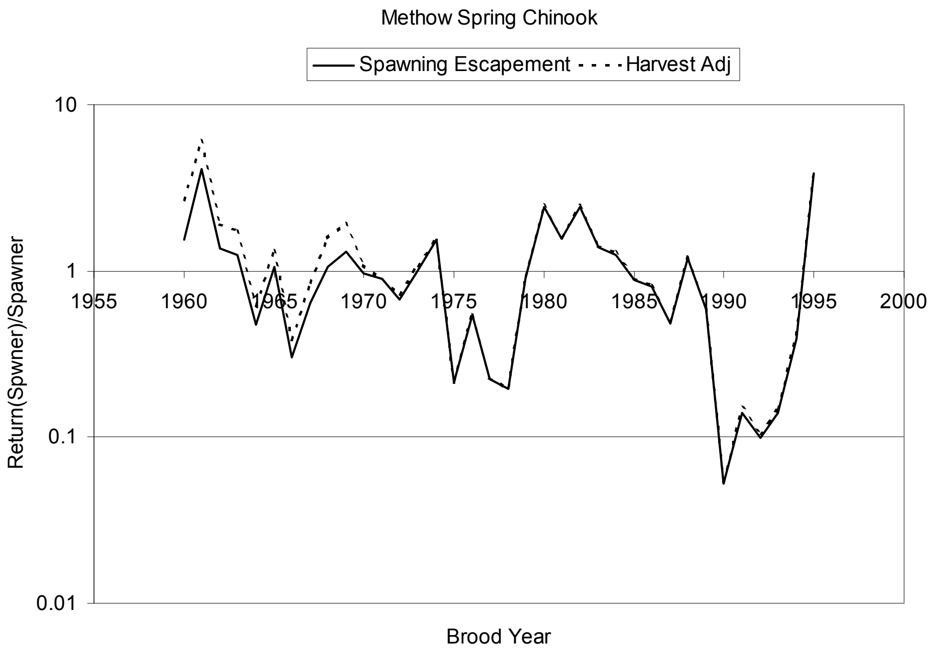


Figure A.2.3.5. Methow spring chinook return/spawner by brood year (returns to spawning grounds).

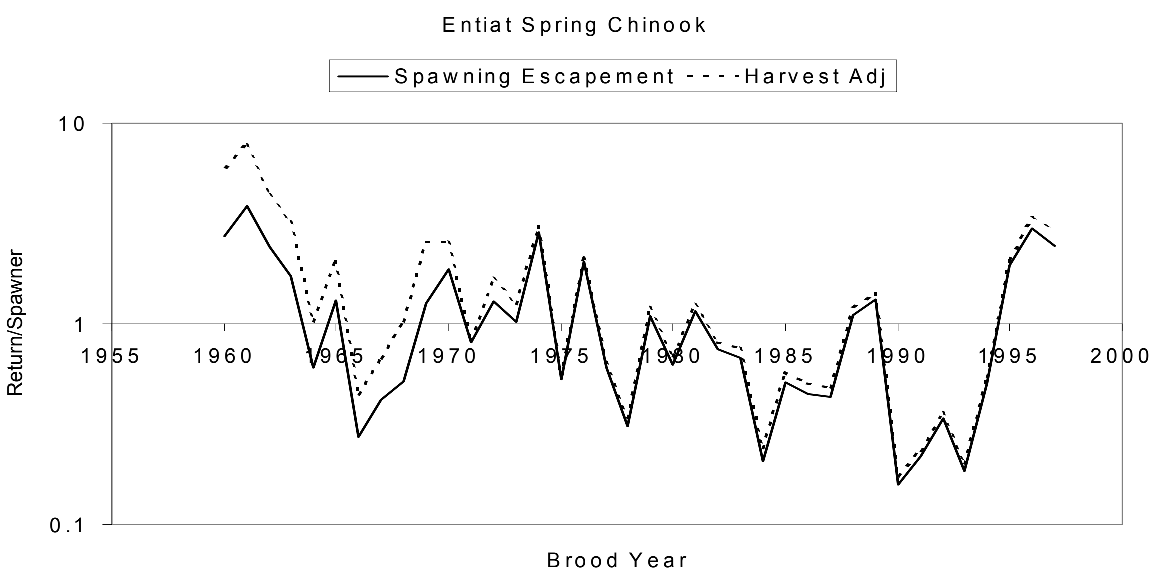


Figure A.2.3.6. Entiat spring chinook return/spawner by brood year (returns to spawning grounds).

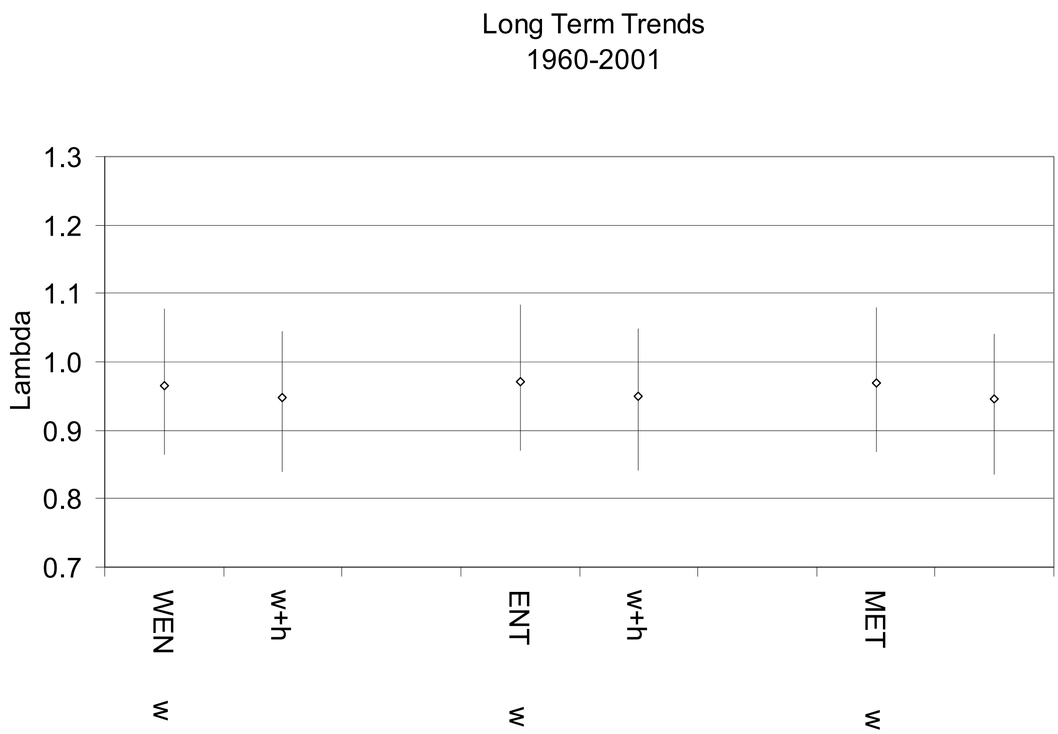


Figure A.2.3.7. Long-term annual growth rates (λ) for upper Columbia Spring chinook populations.

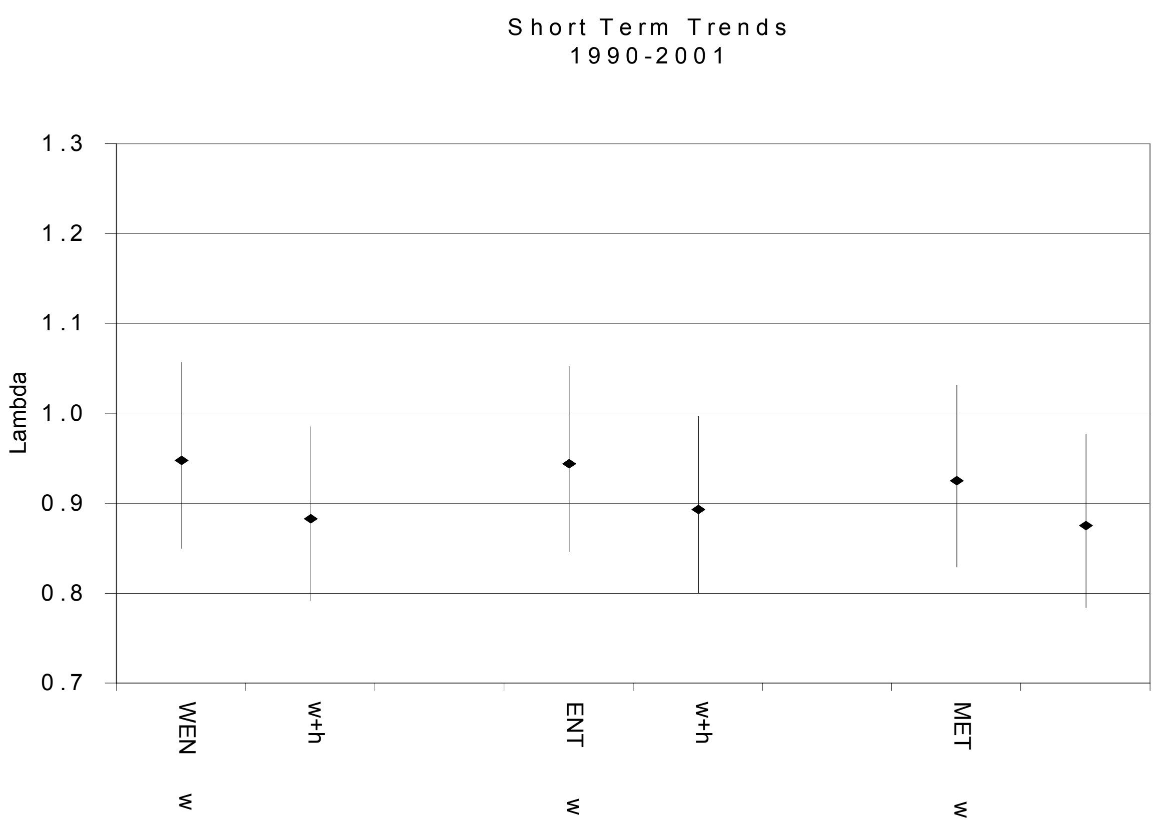


Figure A.2.3.8. Short-term (1990-2001) annual growth rates (λ) for upper Columbia Spring chinook populations.

A.2.4 PUGET SOUND CHINOOK SALMON

A.2.4.1 Previous BRT conclusions

Status and trends

The BRT concluded in 1999 that the Puget Sound chinook ESU was likely to become endangered in the foreseeable future. The estimated total run size of chinook salmon to Puget Sound in the early 1990s was 240,000 chinook, down from an estimated 690,000 historic run size. The 5-year geometric mean of spawning escapement of natural chinook salmon runs in North Puget Sound during the period from 1992-1996 was approximately 13,000. Both long- and short-term trends for these runs were negative, with few exceptions. In south Puget Sound, spawning escapement of the natural runs averaged 11,000 spawners at the time of the last status review update. In this area, both long- and short-term trends were predominantly positive. In Hood Canal, spawning populations in six streams were considered a single stock by the co-managers because of extensive transfers of hatchery fish (WDF et al. 1993). Fisheries in the area were managed primarily for hatchery production and secondarily for natural escapement; high harvest rates directed at hatchery stocks resulted in failure to meet natural escapement goals in most years (USFWS 1997a). The 5-year geometric mean natural spawning escapement at the time of the last update was 1,100, with negative short- and long-term trends (except in the Dosewallips River). The ESU also included the Dungeness and Elwha Rivers, which had natural chinook salmon runs as well as hatcheries. The Dungeness River had a run of spring/summer-run chinook salmon with a 5-year geometric mean natural escapement of 105 fish at the time of the last status review update. The Elwha River has a 5-year geometric mean escapement of 1,800 fish during the mid-1990s, which included a large, but unknown fraction of naturally spawning hatchery fish. Both the Elwha and Dungeness populations exhibited downward trends in abundance in the 1990s.

Threats

Habitat throughout the ESU has been blocked or degraded. In general, upper tributaries have been impacted by forest practices and lower tributaries and mainstem rivers have been impacted by agriculture and/or urbanization. Diking for flood control, draining and filling of freshwater and estuarine wetlands, and sedimentation due to forest practices and urban development are cited as problems throughout the ESU (WDF et al. 1993). Blockages by dams, water diversions, and shifts in flow regime due to hydroelectric development and flood control projects are major habitat problems in several basins. Bishop and Morgan (1996) identified a variety of critical habitat issues for streams in the range of this ESU, including changes in flow regime (all basins), sedimentation (all basins), high temperatures (Dungeness, Elwha, Green/Duwamish, Skagit, Snohomish, and Stillaguamish Rivers), streambed instability (most basins), estuarine loss (most basins), loss of large woody debris (Elwha, Snohomish, and White Rivers), loss of pool habitat (Nooksack, Snohomish, and Stillaguamish Rivers), and blockage or passage problems associated with dams or other structures (Cedar, Elwha, Green/Duwamish, Snohomish, and White Rivers). The Puget Sound Salmon Stock Review Group (PFMC 1997a) provided an extensive review of habitat conditions for several of the stocks in this ESU. It concluded that reductions in habitat capacity and quality have contributed to escapement problems for Puget Sound chinook, citing evidence of direct losses of tributary and mainstem habitat due to dams, and of slough and side-channel habitat due to diking, dredging, and hydromodification. It also cited reductions in habitat quality due to land management activities.

WDF et al. (1993) classified 11 out of 29 stocks in this ESU as being sustained, in part, through artificial propagation. Nearly 2 billion fish have been released into Puget Sound tributaries since the 1950s (Myers et al. 1998). The vast majority of these have been derived from local returning fall-run adults. Returns to hatcheries have accounted for 57% of the total spawning escapement, although the hatchery contribution to spawner escapement is probably much higher than that, due to hatchery-derived strays on the spawning grounds. Almost all of the releases into this ESU have come from stocks within this ESU, with the majority of within ESU transfers coming from the Green River Hatchery or hatchery broodstocks that have been derived from Green River stock (Marshall et al. 1995). The electrophoretic similarity between Green River fall-run chinook salmon and several other fall-run stocks in Puget Sound (Marshall et al. 1995) suggests that there may have been a significant effect from some hatchery transplants. Overall, the pervasive use of Green River stock throughout much of the extensive hatchery network that exists in this ESU may reduce the genetic diversity and fitness of naturally spawning populations.

Harvest impacts on Puget Sound chinook salmon stocks were quite high. Ocean exploitation rates on natural stocks averaged 56%-59%; total exploitation rates averaged 68%-83% (1982-89 brood years) (PSC 1994). Total exploitation rates on some stocks have exceeded 90% (PSC 1994).

Previous assessments of stocks within this ESU have identified several stocks as being at risk or of concern (reviewed in Myers et al. 1998).

A.2.4.2 New Data

ESU status at a glance

Historical peak run size	~690,000
Historical populations	31
Extant populations	22
5-year geometric mean natural spawners per population	42 – 7,000
Long-term λ per population	0.89 – 1.2 (H0); 0.7 – 1.1 (H1)
Recent λ per population	0.90 – 1.2 (H0); 0.65 – 1.2 (H1)
Listing status	Threatened

Table A.2.4.1. Number of populations in the ESU of each life history type. Populations with "some current natural production" have some natural origin recruits present but are not necessarily considered naturally self-sustaining ("viable"). (Evidence for presumed historical population structure for the ESU is summarized in Myers et al. [1998]; and estimates of "viable" populations are based on preliminary analyses conducted by the Puget Sound TRT.)

	Life-History Type		
	Late run	**Early run**	**Total**
Historical	17	14	31
Some current natural production	16	6	22
Currently "viable" populations	2-4	0-2	2-6

ESU structure

The Puget Sound ESU is comprised of 31 historically quasi-independent populations of chinook, 22 of which are believed to be extant currently (PSTRT 2001 and 2002) (Table A.2.4.1). The populations that are presumed to be extinct are mostly of early-returning fish, and most of these are in the mid- to southern parts of the Puget Sound or in Hood Canal/Strait of Juan de Fuca (Table A.2.4.2). The populations in the ESU with the greatest estimated fractions of hatchery fish tend to be in the mid- to southern parts of Puget Sound, in Hood Canal, and in the Strait of Juan de Fuca (Table A.2.4.3).

Table A.2.4.2. Historical populations of chinook salmon in the Puget Sound ESU. Run-timing types for each population and the biogeographic region within which each population occurs also are noted (Puget Sound TRT 2001 and 2002).

Population	Status	Run-Timing	Bio-Geographic Region	Reference
North Fork Nooksack	Extant	early	Strait of Georgia	
South Fork Nooksack	Extant	early	Strait of Georgia	
Nooksack late	Extinct	late	Strait of Georgia	PS TRT 2001
Lower Skagit	Extant	late	Whidbey Basin	
Upper Skagit	Extant	late	Whidbey Basin	
Lower Sauk	Extant	late	Whidbey Basin	
Upper Sauk	Extant	early	Whidbey Basin	
Suiattle	Extant	early	Whidbey Basin	
Upper Cascade	Extant	early	Whidbey Basin	
North Fork Stillaguamish	Extant	late	Whidbey Basin	
South Fork Stillaguamish	Extant	late	Whidbey Basin	
Stillaguamish early	Extinct	early	Whidbey Basin	Nehlsen et al. 1991; WDF et al. 1993
Skykomish	Extant	late	Whidbey Basin	
Snoqualmie	Extant	late	Whidbey Basin	
Snohomish early	Extinct	early	Whidbey Basin	Nehlsen et al. 1991; WDF et al. 1993
Cedar	Extant	late	Main Basin/ South Basin	
North Lake Washington	Extant	late	Main Basin/ South Basin	
Green/Duwamish	Extant	late	Main Basin/ South Basin	
Green/Duwamish early	Extinct	early	Main Basin/ South Basin	Nehlsen et al. 1991; WDF et al. 1993
Puyallup	Extant	late	Main Basin/ South Basin	
White	Extant	early	Main Basin/ South Basin	
Puyallup early	Extinct	early	Main Basin/ South Basin	Nehlsen et al. 1991
Nisqually	Extant	late	Main Basin/ South Basin	
Nisqually early	Extinct	early	Main Basin/ South Basin	Nehlsen et al. 1991; ONRC 1995
Skokomish	Extant	late	Hood Canal	
Skokomish early	Extinct	early	Hood Canal	Deschamps 1954; Nehlsen et al. 1991; WDF et al. 1993

Table A.2.4.2 continued

Dosewallips	Extant	late	Hood Canal	
Dosewallips early	Extinct	early	Hood Canal	Nehlsen et al. 1991; ONRC 1995
Dungeness	Extant	late	Strait of Juan de Fuca	
Elwha	Extant	late	Strait of Juan de Fuca	
Elwha early	Extinct	early	Strait of Juan de Fuca	Nehlsen et al. 1991; WDF et al. 1993

A.2.4.3. Updated Analyses

Abundance of natural spawners

The most recent 5-year geometric mean natural spawner numbers in populations of Puget Sound chinook ranges from 42 (in the Dosewallips) to just over 7,000 fish (in the upper Skagit population). Most populations contain natural spawners numbering in the hundreds (median recent natural escapement = 481); and of the six populations with greater than 1,000 natural spawners, only two are thought to have a low fraction of hatchery fish (Table A.2.4.3; Figure A.2.4.1). Estimates of the fraction of natural spawners that are of hatchery origin are sparse—data are available for only seven of the 22 populations in the ESU, and such information is available for only the most recent 5 years or so. Estimates of the hatchery fraction of natural spawners come from counts of otolith-marked local hatchery fish sampled from carcasses (Nooksack River Basin, Snohomish River Basin), adipose fin clip counts from redd count surveys (Skagit River Basin), and coded-wire tag sampling (NF Stillaguamish and Green River). In general, populations in the Skagit river basin are the only ones with presumed low estimates of naturally spawning hatchery fish. The Stillaguamish and Snohomish populations have moderate estimates of naturally spawning hatchery fish. Estimates of historical equilibrium abundance from predicted pre-European settlement habitat conditions range from 1,700 to 51,000 potential chinook spawners per population. The historical estimates of spawner capacity are several orders of magnitude higher than realized spawner abundances currently observed throughout the ESU.

Table A.2.4.3. Abundance of natural spawners, estimates of the fraction of hatchery fish in natural escapements, and estimates of historical capacity of Puget Sound streams (Puget Sound TRT, unpublished data and Puget Sound co-managers).

Population	**Geometric mean natural spawners (recent 5 y)**	**% hatchery in escapement (mean, min, max)**	**Chinook hatcheries in basin?**	**Hatchery fraction data?**	**EDT estimate of historical capacity[3]**
NF Nooksack	64	19 (3 –57)	Kendall (NF; rm 45)	yes	26,000
SF Nooksack	148	25 (0 - 43)	Kendall (NF; rm 45)	yes	13,000
Lower Skagit	1,537	0	Marblemount (mouth of Cascade)[1]	none	22,000
Upper Skagit	7,332	2(0 - 3)	Marblemount (mouth of Cascade) [1]	yes	35,000
Upper Cascade	268	0	Marblemount (mouth of Cascade) [1]	none	1,700
Lower Sauk	480	0	Marblemount (mouth of Cascade) [1]	none	7,800
Upper Sauk	298	0	Marblemount (mouth of Cascade) [1]	none	4,200
Suiattle	401	0	Marblemount (mouth of Cascade) [1]	none	830
NF Stillaguamish	483	27 (0 – 52)	Tribal (NF)	yes	24,000
SF Stillaguamish	250	NA	Tribal (NF)	none	20,000
Skykomish	1,662	36 (10 - 66)	Wallace R.	yes	51,000
Snoqualmie	1,467	21 (2 – 72)	Wallace R.	yes	33,000
NL Washington	251	NA	Lake Wash, Issaquah, UW	none	NA
Cedar	244	NA	Lake Wash, Issaquah, UW	none	NA
Green	547	70 (0 -100)	Soos, Icy and Keta Cr.	yes	NA
White[2]	735	NA	White R (rm 23); Voights Cr. (Carbon R), Diru (rm 5)	none	NA
Puyallup	2,039	NA	Voights Cr. (Carbon R), Diru (rm 5)	none	33,000
Nisqually	883	NA	Kalama, Clear Cr	none	18,000

Table A.2.4.3 continued

Skokomish	1,105	NA	George Adams (Purdy Cr., lower Skok)	none	NA
Dosewallips	42	NA	none	none	4,700
Dungeness[2]	132	NA	Dungeness (and Hurd Cr)	none	8,100
Elwha	821	NA	Tribal (rm 1) and State (rm 3.2)	none	NA

[1]Summer-run chinook hatchery program discontinued; last returns in 1996.
[2]Captive broodstock program in place.
[3] Estimates of historical habitat capacity based on an EDT analysis conducted by the co-managers in Puget Sound (PSTRT 2002).

Trends in natural spawners

Long-term trends in abundance and median population growth rates for naturally spawning populations of chinook in Puget Sound both indicate that approximately half of the populations are declining and half are increasing in abundance over the length of available time series (Table A.2.4.4; Fig. A.2.4.2). Long-term population growth rates (λ) were calculated under two assumptions about the reproductive success of naturally spawning hatchery fish: the reproductive success was 0 (i.e., HO), or the reproductive success was equivalent to that of wild fish (i.e., H1). Calculations of long-term λ for Puget Sound chinook populations were not greatly affected by the assumptions about the reproductive success of hatchery fish because of the dearth of information on the fraction of hatchery fish in time series (Table A.2.4.4). The median over all populations of long-term population growth rates is $\lambda = 1.001$ (regardless of assumptions about hatchery fish reproduction), indicating that most populations are just replacing themselves. Similarly, the probability that the long-term trend (median across populations = 0.8, mean = 0.6) or long-term λ (median across populations = 0.4, mean = 0.52-0.58) are less than one indicate that on average, populations have declining trends and stable growth rates (Table A.2.4.5). In those cases where hatchery information is available (e.g., North Fork Nooksack, Green River), the effect of the reproductive success of hatchery fish assumption on estimates of λ is dramatic. The most extreme declines in natural spawning abundance have occurred in the North Fork Nooksack, North Fork Stillaguamish, Green, and Elwha populations over the long term. All of those populations likely have a moderate to high fraction of naturally spawning hatchery fish. Those populations with the greatest long-term population growth rates are the Upper Cascade, White, Puyallup, and Dosewallips; all of which likely have a high fraction of naturally spawning hatchery fish except for the Upper Cascade.

The number of populations with declining abundance over the short term is similar to long-term trends--8 of 22 (short-term trend) and 11-12 of 22 (short-term λ) populations in the ESU are declining. The median short-term λ over all populations is similar to long-term estimates of λ, except when the reproductive success of hatchery fish is assumed to be 1 (median short term λ-H0 = 1.003; median short-term λ–H1 = 0.995). The probability that the short-term trend (median across populations = 0.4, mean = 0.5) or short-term λ (median across populations = 0.5, mean = 0.48-0.57) are less than one indicate that on average, populations have stable to slightly increasing trends and mixed positive and negative growth rates (Table A.2.4.5). The most extreme short-term declines in natural spawner abundance have occurred in the North Fork Nooksack, Green River, and Elwha populations. All of these populations are likely to have high fractions of hatchery fish—the Green River population has one of the highest estimated fractions of hatchery fish spawning naturally in the Puget Sound area. The populations with the most positive short-term trends and population growth rates are the Upper Skagit, White River, and Dosewallips populations. Of this group, only the Upper Skagit population is thought to have a low fraction of naturally spawning hatchery fish.

Table A.2.4.4. Estimates of long- and short-term trend, median population growth rate (λ), and their 95% confidence intervals for spawners in Puget Sound chinook populations (data are from the Puget Sound TRT, unpublished data). "H0" and "H1" indicate whether λ is calculated assuming the reproductive success of naturally spawning hatchery fish is 0 or equivalent to that of wild fish.

Population	Data years	LT Trend (CI)	LT λ (H0) (CI)	LT λ (H1) (CI)	ST Trend (CI)	ST λ (H0) (CI)	ST λ (H1) (CI)
NF Nooksack	1984-2001	0.95 (0.852-1.058)	0.942 (0.804-1.103)	0.804 (0.651-0.9)	1.003 (0.791-1.271)	0.898 (0.766-1.051)	0.703 (0.598-0.826)
SF Nooksack	1984-2001	0.964 (0.913-1.018)	0.972 (0.83-1.138)	0.922 (0.784-1.084)	1.016 (0.918-1.124)	0.999 (0.853-1.17)	0.921 (0.783-1.083)
Lower Skagit	1952-2001	0.983 (0.972-0.994)	1.005 (0.921-1.096)	1.004 (0.921-1.102)	1.016 (0.893-1.156)	1.027 (0.942-1.121)	1.027 (0.939-1.123)
Upper Skagit	1952-2001	0.998 (0.991-1.006)	1.005 (0.921-1.097)	1.001 (0.922-1.231)	1.041 (0.951-1.14)	1.053 (0.965-1.149)	1.048 (0.959-1.147)
Upper Cascade	1984-2001	1.038 (0.992-1.086)	1.036 (0.885-1.213)	1.035 (0.89-1.093)	1.051 (0.959-1.151)	1.067 (0.911-1.249)	1.066 (0.906-1.253)
Lower Sauk	1952-2001	0.991 (0.978-1.005)	1.001 (0.918-1.092)	1.001 (0.914-1.06)	1.009 (0.869-1.171)	0.991 (0.908-1.081)	0.991 (0.906-1.083)
Upper Sauk	1984-2001	0.969 (0.955-0.984)	0.975 (0.894-1.064)	0.975 (0.886-1.094)	0.95 (0.861-1.047)	0.935 (0.857-1.02)	0.935 (0.855-1.022)
Suiattle	1952-2001	0.986 (0.976-0.995)	1 (0.915-1.092)	1 (0.915-1.033)	1.011 (0.925-1.106)	1.006 (0.921-1.1)	1.006 (0.92-1.101)
NF Stillaguamish	1974-2001	0.969 (0.951-0.988)	0.962 (0.852-1.085)	0.923 (0.807-1.127)	0.985 (0.928-1.046)	0.98 (0.869-1.106)	0.882 (0.78-0.999)
SF Stillaguamish	1974-2001	1.018 (0.999-1.038)	1.001 (0.887-1.129)	1.001 (0.879-0.999)	0.984 (0.963-1.006)	0.98 (0.896-1.1)	0.98 (0.866-1.109)
Skykomish	1965-2001	0.984 (0.973-0.996)	0.987 (0.89-1.094)	0.911 (0.809-1.109)	0.995 (0.945-1.047)	0.993 (0.933-1.146)	0.852 (0.767-0.947)
Snoqualmie	1965-2001	1.017 (0.998-1.037)	1.028 (0.927-1.139)	1.001 (0.898-1.196)	1.08 (0.925-1.261)	1.034 (0.924-1.254)	0.984 (0.885-1.094)
NL Washington	1983-2001	0.964 (0.901-1.03)	0.995 (0.854-1.159)	0.995 (0.874-1.08)	1.037 (0.882-1.219)	1.077 (0.831-1.048)	1.077 (0.92-1.259)
Cedar	1971-2001	0.964 (0.943-0.986)	0.966 (0.861-1.085)	0.966 (0.852-0.773)	0.913 (0.822-1.014)	0.933 (0.843-1.058)	0.933 (0.828-1.051)

Table A.2.4.4 continued

Green	1971-2001	1.075 (0.995-1.162)	1.023 (0.913-1.146)	0.698 (0.612-1.226)	0.89 (0.661-1.199)	0.944 (1.034-1.316)	0.654 (0.582-0.735)
White	1974-2001	1.094 (1.029-1.162)	1.057 (0.937-1.192)	1.057 (0.957-1.144)	1.155 (1.065-1.254)	1.166 (0.891-1.118)	1.166 (1.03-1.32)
Puyallup	1971-2001	1.03 (1.01-1.051)	1.024 (0.914-1.148)	1.024 (0.906-1.163)	0.966 (0.9-1.038)	0.998 (0.896-1.175)	0.998 (0.888-1.122)
Nisqually	1979-2001	1.022 (0.961-1.088)	1.006 (0.878-1.152)	1.006 (0.881-1.213)	1.046 (0.901-1.213)	1.026 (0.872-1.246)	1.026 (0.893-1.18)
Skokomish	1987-2001	0.978 (0.916-1.044)	0.988 0.826-1.18)	0.988 (0.842-1.429)	1.038 (0.954-1.129)	1.042 (1.014-1.449)	1.042 (0.868-1.252)
Dosewallips	1981-2001	1.076 (0.862-1.344)	1.174 (0.982-1.403)	1.174 (.991-1.429)	1.177 (0.828-1.675)	1.212 (0.869-1.222)	1.212 (1.01-1.456)
Dungeness	1986-2001	0.991 (0.912-1.076)	1.01 (0.851-1.198)	1.01 (0.851-1.198)	1.02 (0.887-1.173)	1.03 (0.797-1.121)	1.03 (0.869-1.222)
Elwha	1986-2001	0.918 (0.839-1.003)	0.894 (0.754-1.06)	0.894 (0.767-1.089)	0.974 (0.856-1.108)	0.945 (.797-1.121)	0.945 (0.793-1.126)

Table A.2.4.5. Estimates of the probability that short- and long-term trends and λ are less than one for populations of chinook in the Puget Sound ESU. "H0" and "H1" indicate whether λ is calculated assuming the reproductive success of naturally spawning hatchery fish is 0 or equivalent to that of wild fish.

Population	P (LT Trend > 1)	P (LT λ-H0 <1)	P (LT λ-H1 <1)	P (ST Trend < 1)	P (ST λ-H0 <1)	P (ST λ-H1 <1)
NF Nooksack	0.837	0.888	0.998	0.491	0.967	0.998
SF Nooksack	0.914	0.723	0.958	0.367	0.506	0.944
Lower Skagit	0.998	0.433	0.393	0.396	0.397	0.399
Upper Skagit	0.655	0.406	0.358	0.172	0.230	0.250
Upper Cascade	0.049	0.162	0.106	0.127	0.122	0.124
Lower Sauk	0.898	0.486	0.505	0.449	0.528	0.528
Upper Sauk	1.000	0.742	0.791	0.866	0.831	0.831
Suiattle	0.998	0.504	0.489	0.393	0.464	0.464
NF Stillaguamish	0.999	0.884	0.995	0.707	0.657	0.983
SF Stillaguamish	0.034	0.493	0.560	0.930	0.836	0.836
Skykomish	0.996	0.718	1.000	0.583	0.579	1.000
Snoqualmie	0.038	0.170	0.533	0.148	0.268	0.627
NL Washington	0.870	0.536	0.351	0.315	0.198	0.198
Cedar	0.999	0.866	0.911	0.959	0.887	0.887
Green	0.034	0.361	1.000	0.798	0.751	1.000
White	0.003	0.268	0.186	0.001	0.023	0.023
Puyallup	0.002	0.221	0.281	0.845	0.518	0.518
Nisqually	0.232	0.473	0.446	0.259	0.372	0.372
Skokomish	0.766	0.597	0.418	0.176	0.199	0.199
Dosewallips	0.243	0.189	0.170	0.163	0.222	0.222
Dungeness	0.593	0.448	0.448	0.381	0.394	0.394
Elwha	0.971	0.884	0.834	0.673	0.686	0.686

A.2.4.4 Updated Threats Information

The Puget Sound TRT (unpublished data) has estimated adult equivalent fishing rates for each population of chinook in the ESU (Table A.2.4.6). Fishing rates are estimated as the proportion of the available population caught in the ocean (often in mixed fisheries) or in terminal fisheries at each age. These estimates include sport and commercial fishing, and they should include incidental mortalities. Fishing rates are a function of catch and escapement estimates, and usually are based on CWT recoveries and estimates of incidental mortalities and natural mortality constants provided by the CTC.

Harvest rates on Puget Sound chinook populations averaged 75% (median = 85%; range 31-92%) in the earliest 5 years of data availability and have dropped to an average of 44% (median = 45; range 26-63%) in the most recent 5-year period.

Table A.2.4.6. Estimated brood-year harvest rates on populations of Puget Sound chinook (Puget Sound TRT unpublished data).

Population	Data years (broodyear)	Earliest 5-year mean fishing rate (%)	Most recent 5-year mean fishing rate (%)
NF Nooksack	1982 – present	43	26
SF Nooksack	1982 – present	44	26
Lower Skagit	1969 – present	81	61
Upper Skagit	1969 - present	88	63
Upper Cascade	1982 - present	89	56
Lower Sauk	1969 - present	88	63
Upper Sauk	1979 - present	84	55
Suiattle	1979 - present	84	30
NF Stillaguamish	1972 - present	89	52
SF Stillaguamish	1972 - present	89	52
Skykomish	1973 - present	86	49
Snoqualmie	1973 - present	85	45
NL Washington	1981 - present	41	27
Cedar	1969 - present	52	31
Green	1969 - present	82	57
White	1972 - present	90	26
Puyallup	1969 - present	51	30
Nisqually	1977 - present	92	62
Skokomish	1985 - present	92	41
Dosewallips	1985 - present	92	45
Dungeness	1984 - present	31	31
Elwha	1984 - present	64	45

The Puget Sound TRT (unpublished data) has amassed estimates of the total number of hatchery-born chinook salmon returning to streams (Table A.2.4.7). These estimates for each population include the total return—returns to natural spawning grounds and to hatchery racks within a population's geographic boundaries. These estimates do not account for possible strays of hatchery fish from outside the population's boundaries. It is apparent from Table

A.2.4.7 that even populations of chinook in northern Puget Sound (not a hatchery production management area for co-managers) receive significant numbers of hatchery fish returning each year. The Dungeness and White populations are undergoing captive broodstock programs as part of co-manager re-building plans, and so it is likely that a large fraction of the escapements reported in Table A.2.4.3. are hatchery fish.

Table A.2.4.7. Total estimated recent annual average returns of hatchery-born chinook salmon and most recent total releases in streams containing independent populations of chinook in Puget Sound (Puget Sound TRT and B. Waknitz, unpublished data).

<table>
<tr><th>Population</th><th>Average annual hatchery return to stream 1997 – present (min, max)</th><th colspan="2">Most recent (1990-2001) total releases of chinook hatchery juveniles, by life-stage (in millions)</th></tr>
<tr><td>NF Nooksack</td><td>1,734 (0 – 9,169)</td><td colspan="2" rowspan="2">54 (41 fall, 13 spring/summer)</td></tr>
<tr><td>SF Nooksack</td><td>1,287 (0 – 5,515)</td></tr>
<tr><td>Lower Skagit</td><td>see Upper Skagit</td><td colspan="2" rowspan="7">12 (3 fall, 5 spring, 4 summer)</td></tr>
<tr><td>Upper Skagit</td><td>1,031 (0 – 4,028)</td></tr>
<tr><td>Upper Cascade</td><td>see Upper Skagit</td></tr>
<tr><td>Lower Sauk</td><td>see Upper Skagit</td></tr>
<tr><td>Upper Sauk</td><td>see Upper Skagit</td></tr>
<tr><td>Suiattle</td><td>see Upper Skagit</td></tr>
<tr><td>NF Stillaguamish</td><td>318 (0 – 777)</td><td colspan="2" rowspan="2">1 summer (plus additional marine releases)</td></tr>
<tr><td>SF Stillaguamish</td><td>see NF Stillaguamish</td></tr>
<tr><td>Skykomish</td><td>3,666 (824 – 8,530)</td><td colspan="2" rowspan="2">22 (11 fall, 11 summer)</td></tr>
<tr><td>Snoqualmie</td><td>2,921 (19 – 6,514)</td></tr>
<tr><td>NL Washington</td><td>NA</td><td colspan="2" rowspan="2">26 fall</td></tr>
<tr><td>Cedar</td><td>NA</td></tr>
<tr><td>Green</td><td>13,565 (3,211 – 23,744)</td><td colspan="2">48 fall</td></tr>
<tr><td>White</td><td>NA</td><td rowspan="2">24.1 (20 fall, 4.1 spring—net pens)</td><td rowspan="3">70 fall in South Sound general</td></tr>
<tr><td>Puyallup</td><td>2,048 (248 – 3,484)</td></tr>
<tr><td>Nisqually</td><td>2,559 (0 – 13,481)</td><td>10 fall</td></tr>
<tr><td>Skokomish</td><td>3,621 (294 – 8,816)</td><td colspan="2" rowspan="2">89 (71 fall, 18 spring)</td></tr>
<tr><td>Dosewallips</td><td>NA</td></tr>
<tr><td>Dungeness</td><td>NA</td><td colspan="2">6 spring</td></tr>
<tr><td>Elwha</td><td>1,332 (663 – 2,595)</td><td colspan="2">27 fall</td></tr>
</table>

Table A.2.4.8 lists hatchery stocks of chinook in Puget Sound and provides the scores from the SSHAG (2003) categorizations of hatchery populations.

Table A.2.4.8. Preliminary SSHAG (2003) categorizations of hatchery populations of the Puget Sound chinook salmon ESU. See "Artificial Propagation" in General Introduction for explanation of the categories.

Stock	Run	Basin	SSHAG Category
Kendall Creek	Spring	Nooksack	2
Lummi Bay	Fall	Nooksack	3
Samish River	Fall	Samish	3
Marblemount	Spring	Skagit	2
Marblemount	Spring	Skagit	1
Marblemount	Fall	Skagit	1
Tulalip	Spring	Tulalip Bay	3
Tulalip	Summer	Tulalip Bay	3
Tulalip	Fall	Tulalip Bay	3
N. Fork Stillaguamish	Summer	Stilliguamish	1
Wallace River	Summer	Snohomish	2
Issaquah Hatchery	Fall	Lake Washington	3
UW Portage Bay	Fall	Lake Washington	3
Soos Creek	Fall	Green	1 or 2
Keta Creek	Fall	Green	1 or 2
Grover's Creek	Fall	East Kitsap	3
Garrison Springs	Fall	Chambers Creek	3
Voights Creek	Fall	Puyallup	3
Diru Creek	Fall	Puyallup	3
White River	Spring	Puyallup	2
Clear/Kalama Creeks	Fall	Nisqually	3
Minter Creek	Fall	S. Sound	3
Tumwater Falls	Fall	Deschutes	3
George Adams	Fall	Skokomish	3
WSC Hood Canal	Fall	Skokomish	3
Finch Creek	Fall	S. Hood Canal	3
Hamma Hamma	Fall	S. Hood Canal	3
Big Beef Creek	Fall	N. Hood Canal	3
Dungeness	Spring	Dungeness	1
Elwha	Fall	Elwha	1 or 2
Glenwood Springs	Fall	San Juan Islands	3

A.2.4.5 Comparison with Previous Data

Overall, the natural spawning escapement estimates for Puget Sound chinook populations are very similar to those at the time of the previous status review of Puget Sound chinook conducted with data through 1997. The differences between population escapement estimates between the previous status assessments using data from 1997 and the present assessment using data through 2001 could be due to (1) revised pre-1997 data, (2) differences in which fish are counted as part of a population, (3) new information on the fraction of natural spawners that are hatchery fish, or (4) true differences reflected in new data on natural spawners obtained over the most recent 4 years. The median across populations of the most recent 5-year geometric mean natural escapement for the same 22 populations through 1997 was N = 438 (compared to N = 481 through 2001), and the range was 1-5,400. A few more populations increased (n = 13) in their geometric mean escapements as decreased (n = 9) over the past 4 years. The most dramatic change in recent natural escapement estimates from the previous status assessment was in the Green River—the recent natural escapement estimate is lower than the previous one by almost 5,000 spawners. This apparent drop in natural escapement is due primarily to new information about the fraction of hatchery fish that are spawning naturally.

Throughout the ESU, the estimates of trends in natural spawning escapements for Puget Sound chinook populations are similar to the previous status review of Puget Sound chinook conducted with data through 1997. As stated above for escapement estimates, the differences in trend estimates between the previous status assessments using data from 1997 and the present assessment using data through 2001 could be due to (1) revised pre-1997 data, (2) differences in which fish are counted as part of a population, (3) new information on the fraction of natural spawners that are hatchery fish, or (4) true differences reflected in new data on natural spawners obtained over the most recent 4 years. The median across populations of the long-term trend in natural spawners was a 1.1% decline per year through 1997, compared to a median 1.2% decline per year through 2001. Twelve populations had declining long-term trends through 1997, and 14 populations have declining long-term trends through 2001. Short-term trends are generally less negative in more recent years—the median trend across 22 populations through 1997 was a -4% decline per year, and the median trend through 2001 was a 1.4% increase per year. Fourteen populations showed declining short-term trends at the time of the previous status reviews, and only eight populations exhibit declining short-term trends in recent years.

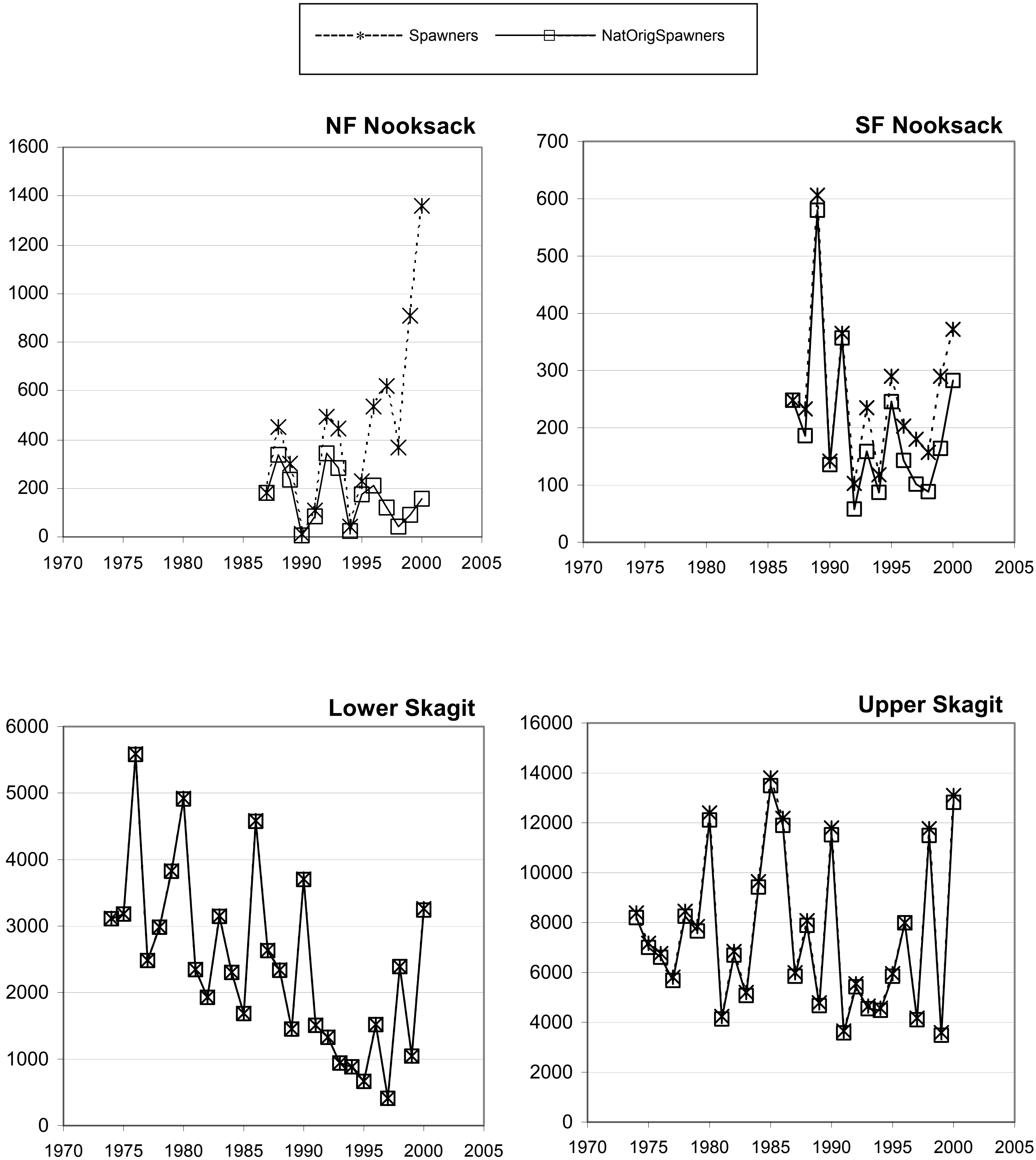
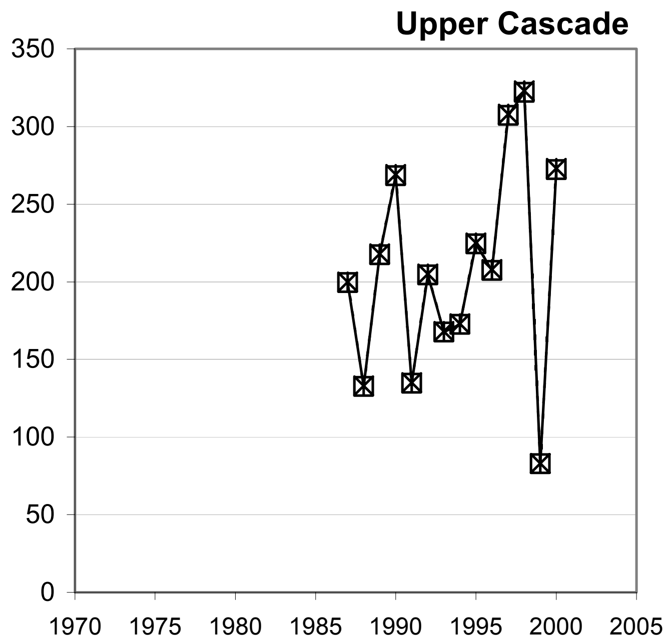


Figure A.2.4.1. Abundance of spawning chinook in Puget Sound. Where available, the fraction of natural spawners that are hatchery-origin fish also are reported.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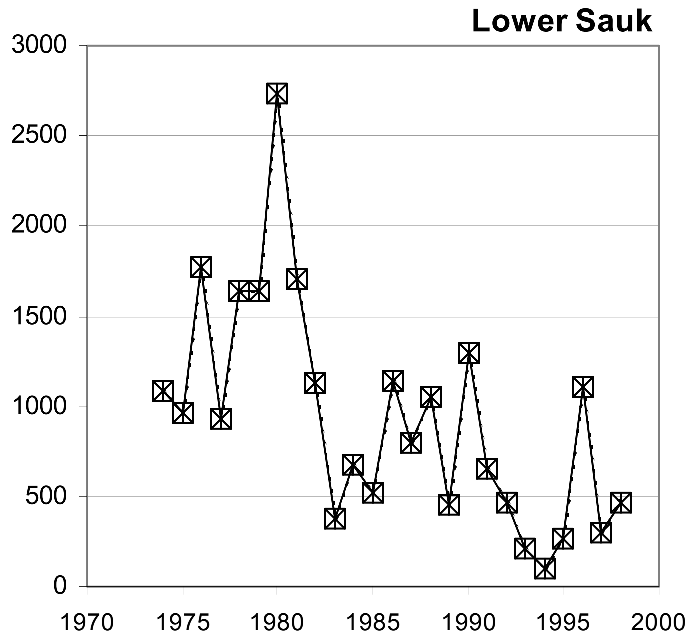
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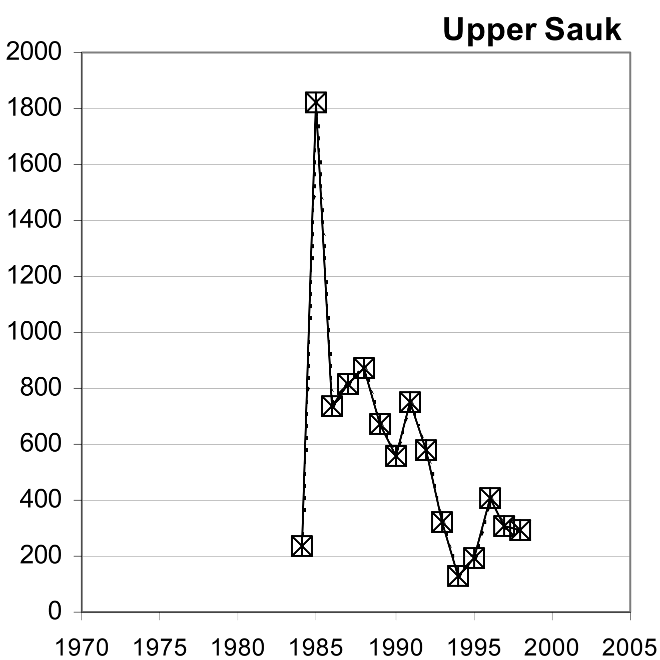
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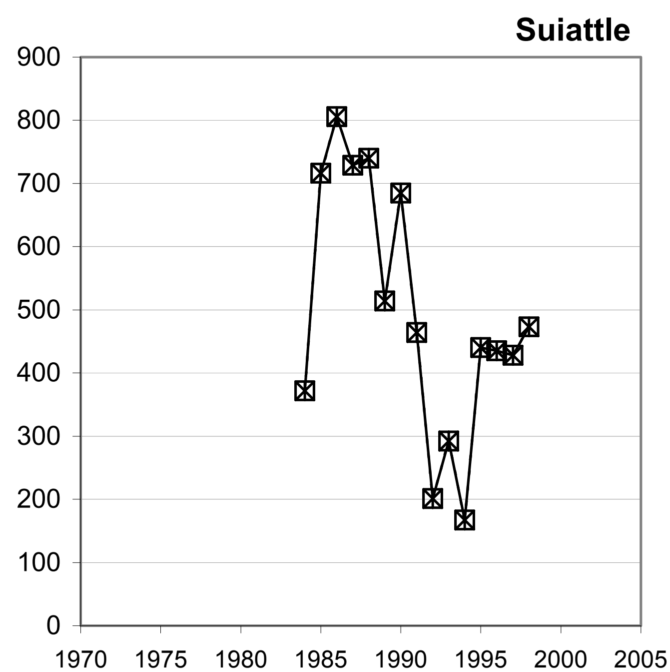
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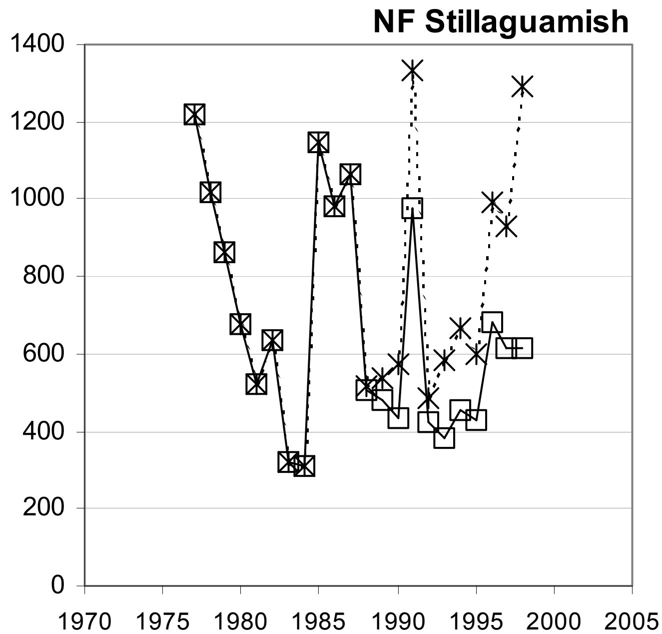
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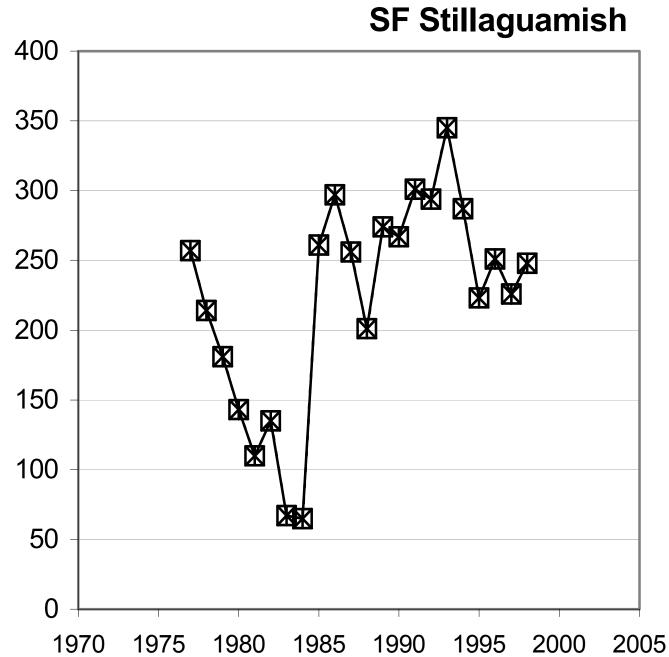
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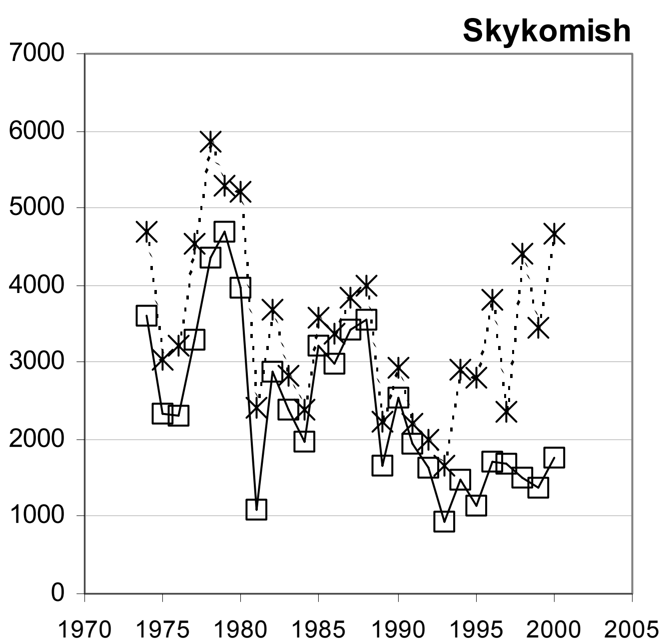
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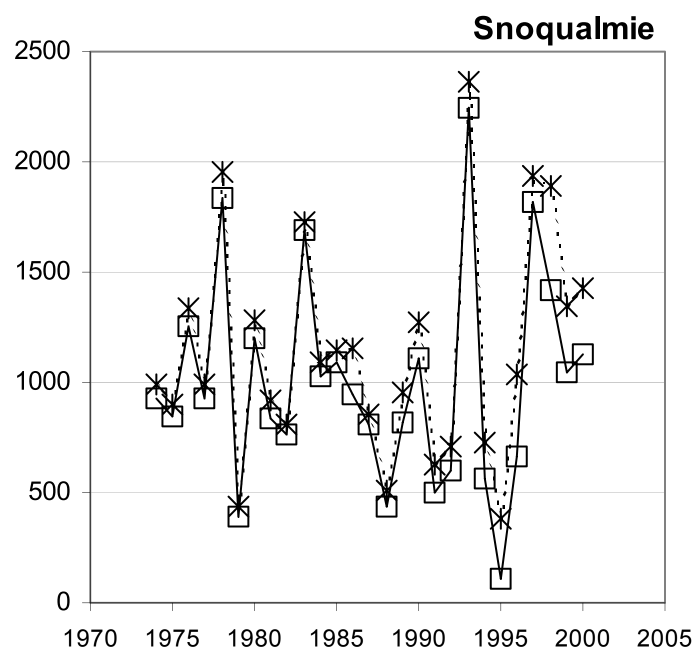
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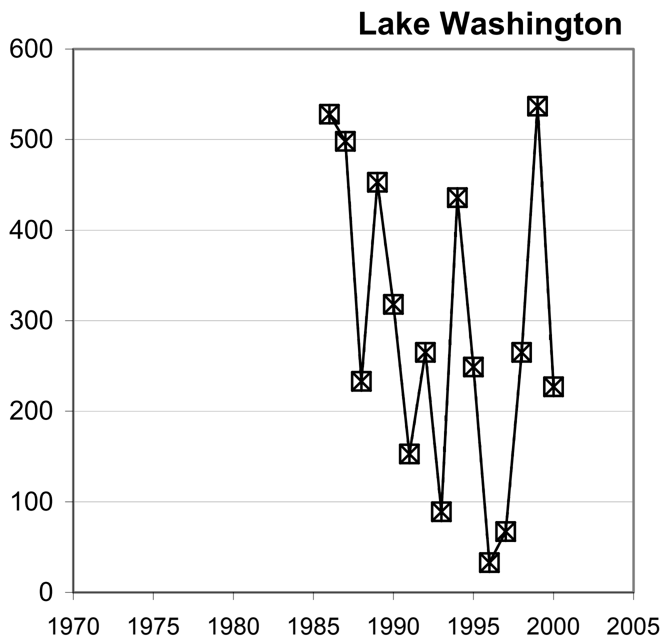
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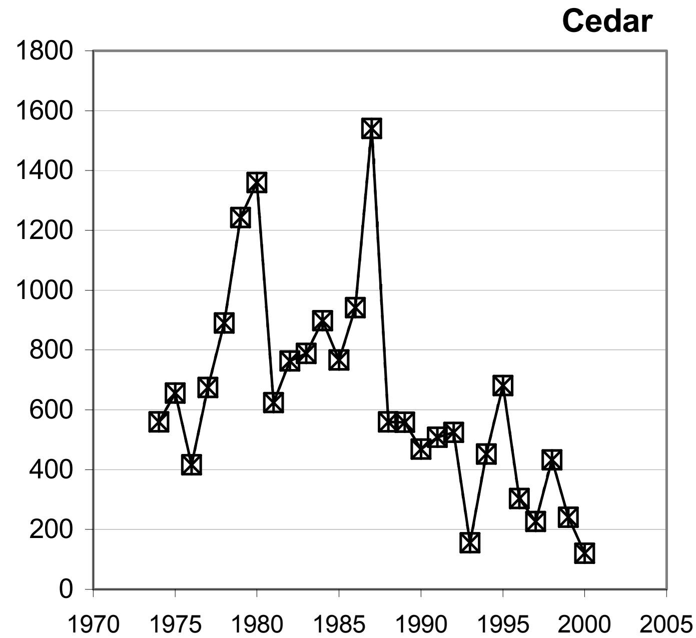
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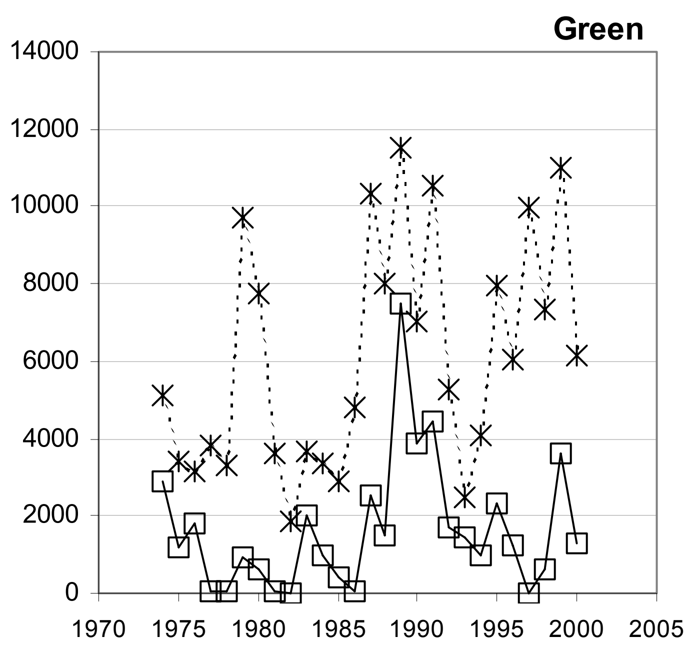
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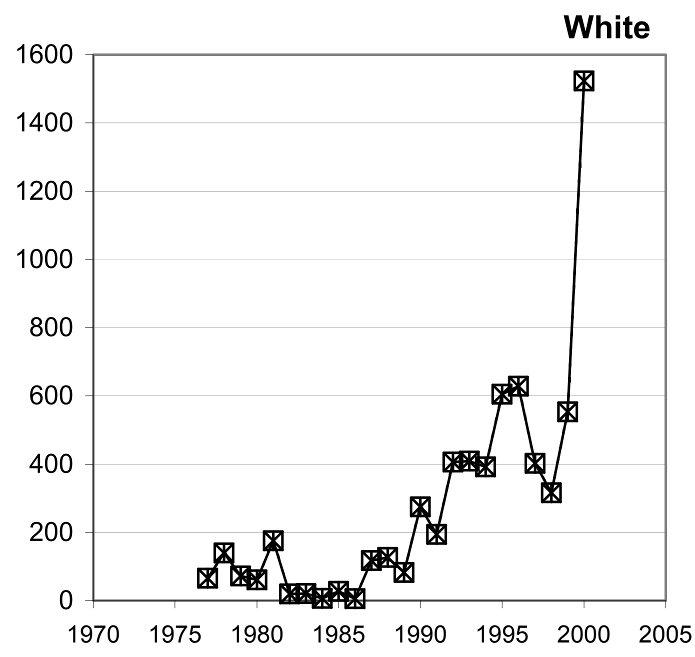
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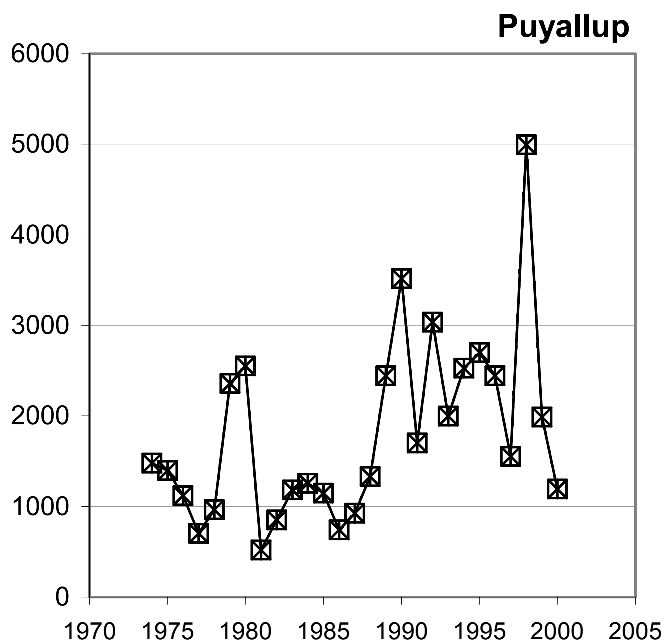
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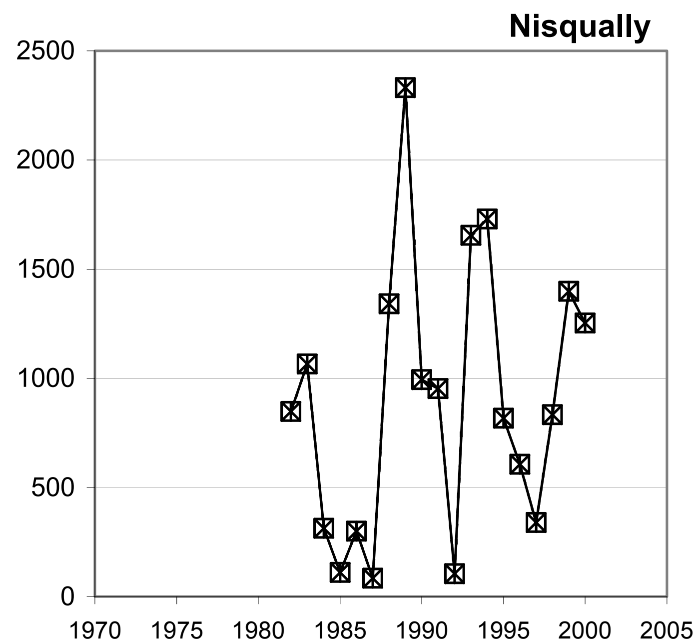
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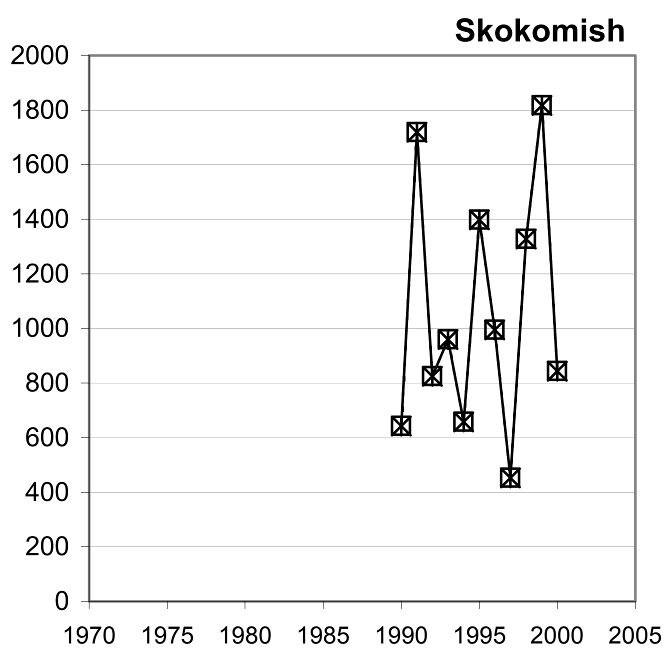
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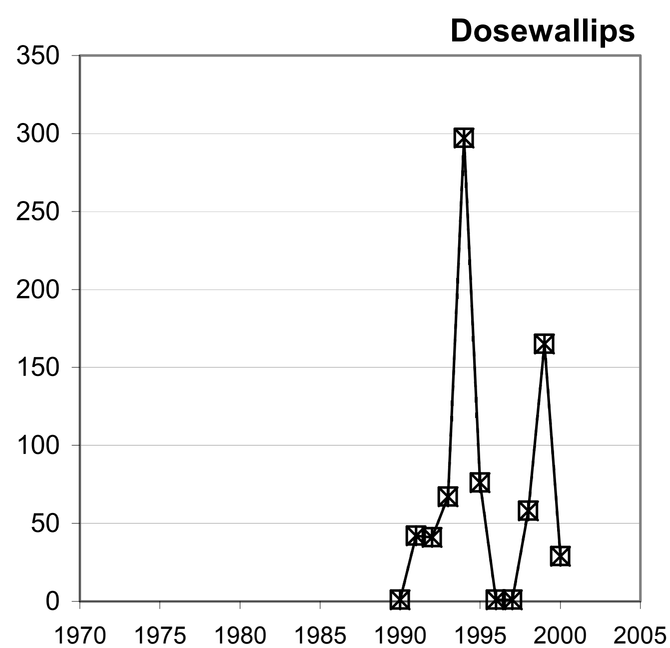
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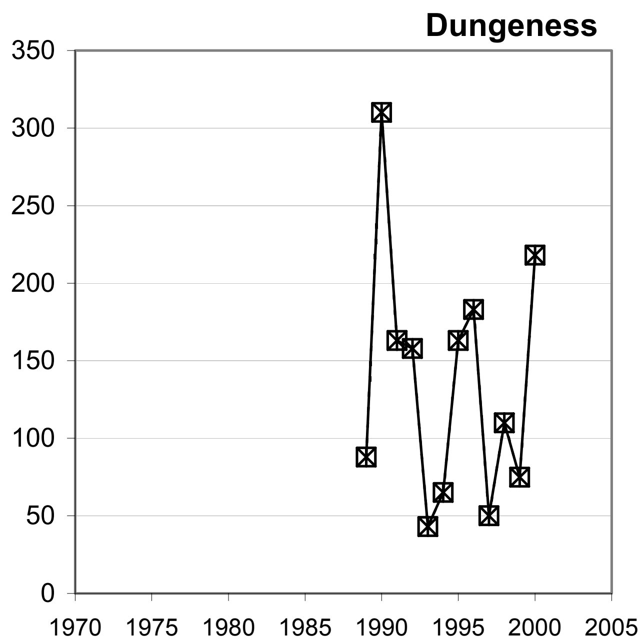
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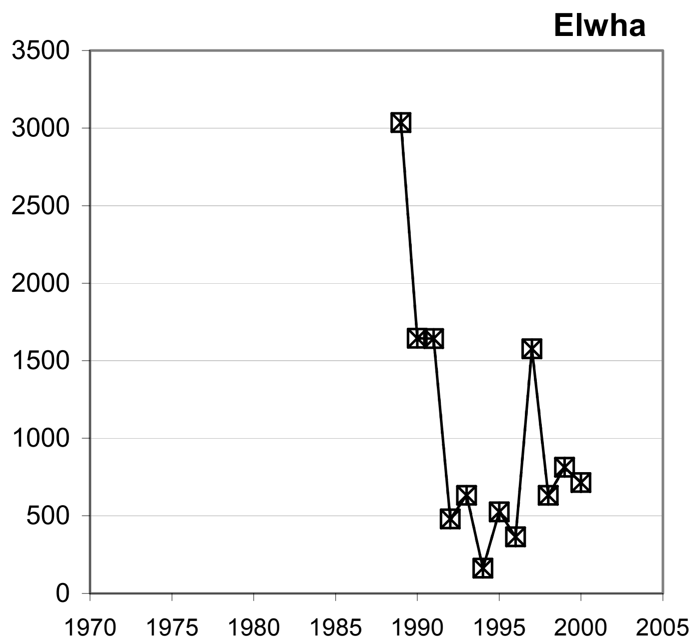
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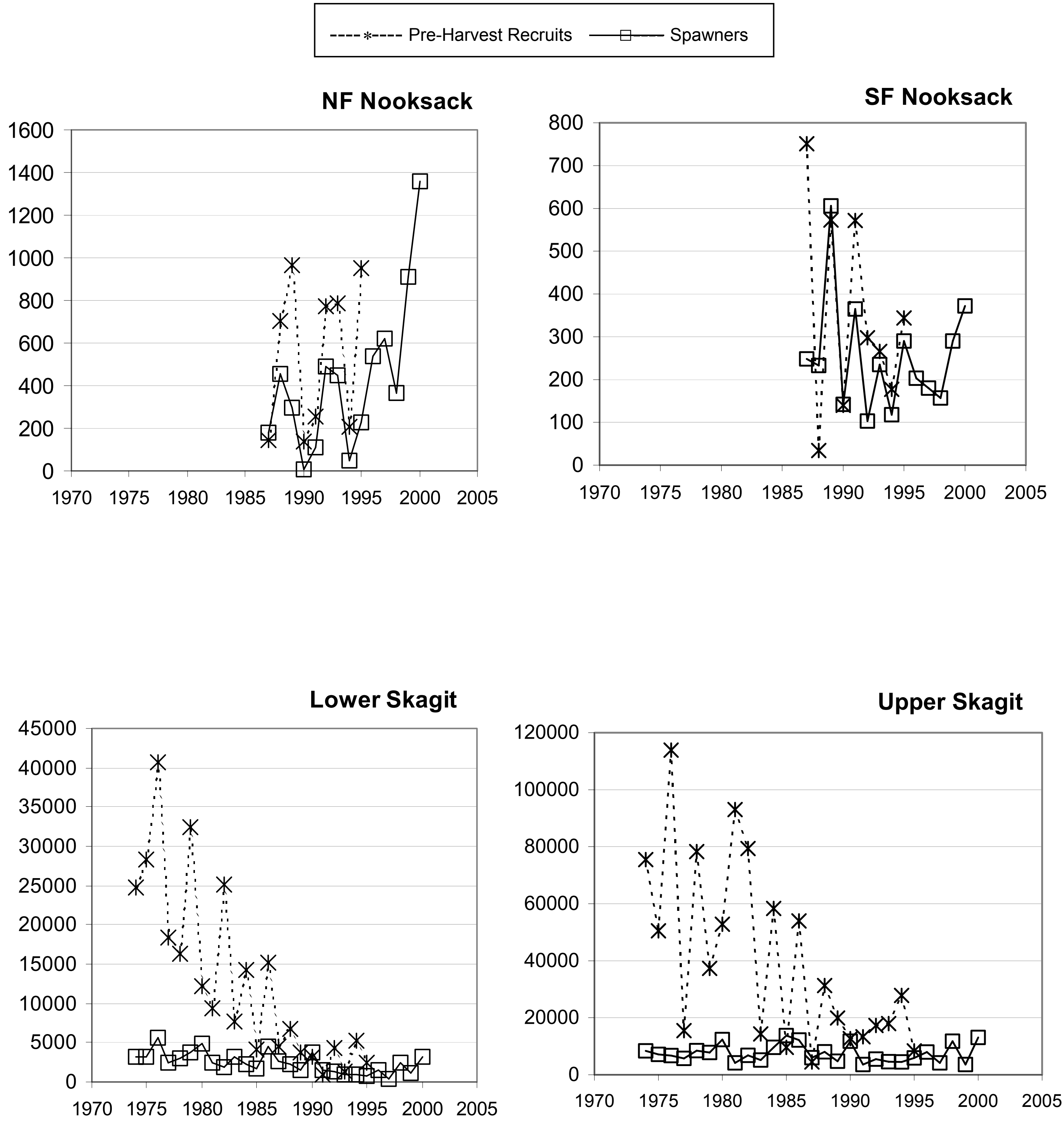
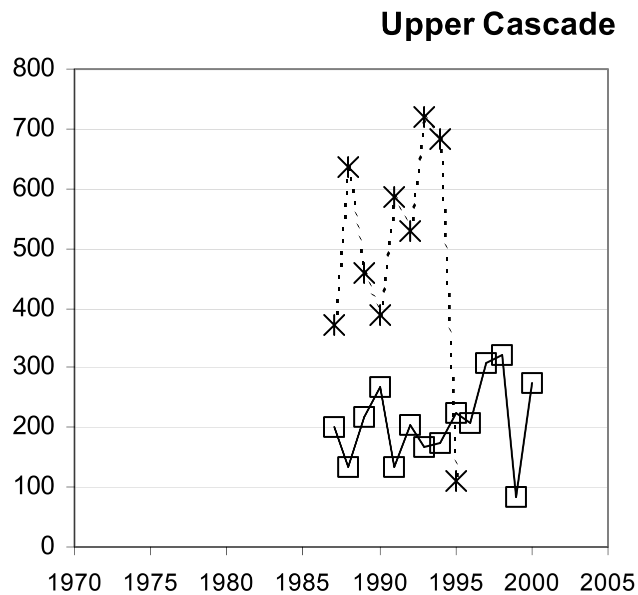


Figure A.2.4.2. Abundance of spawners and pre-harvest recruits to chinook populations in Puget Sound.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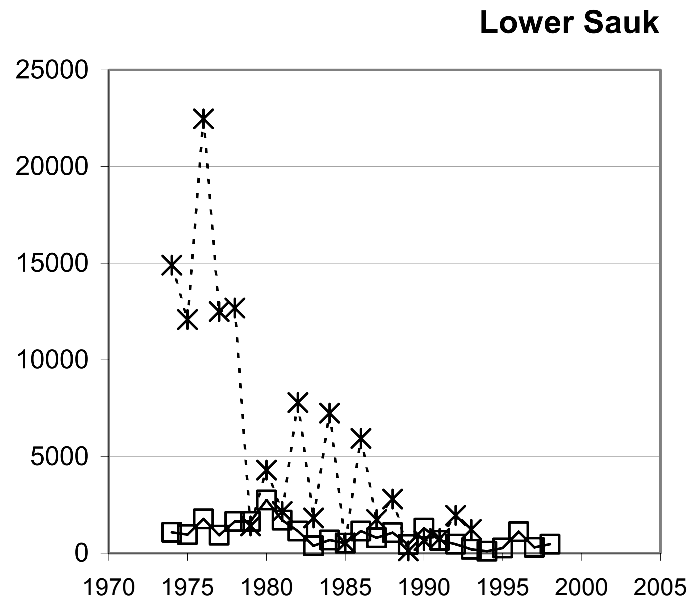
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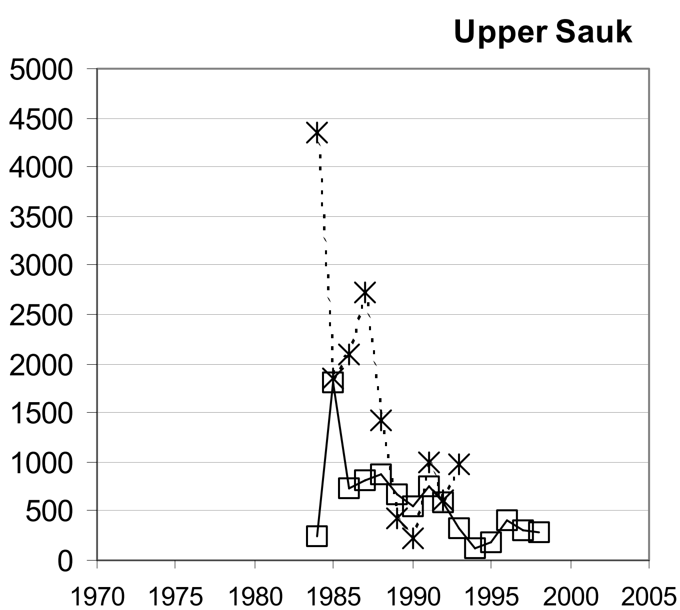
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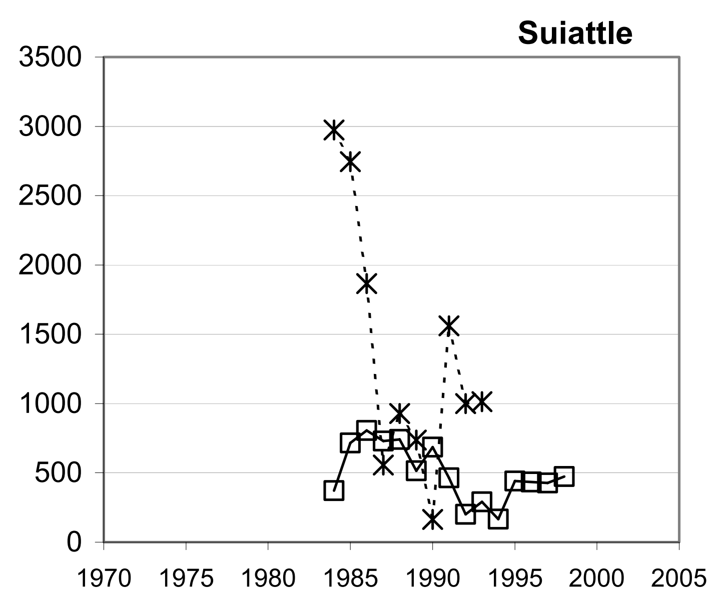
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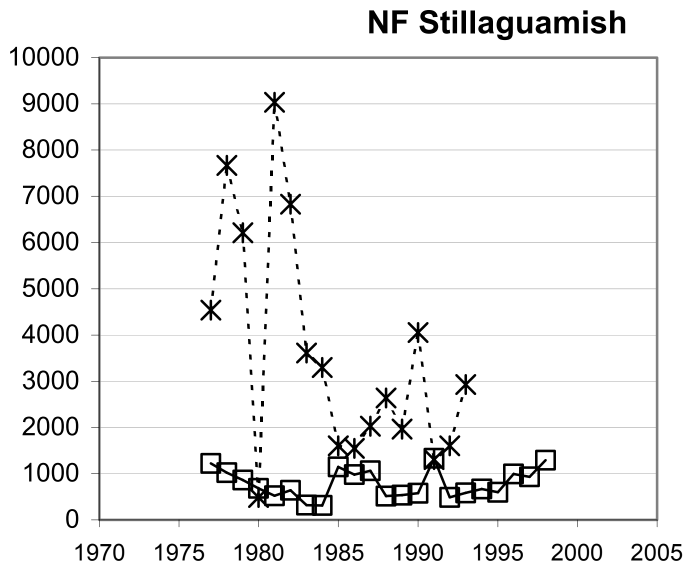
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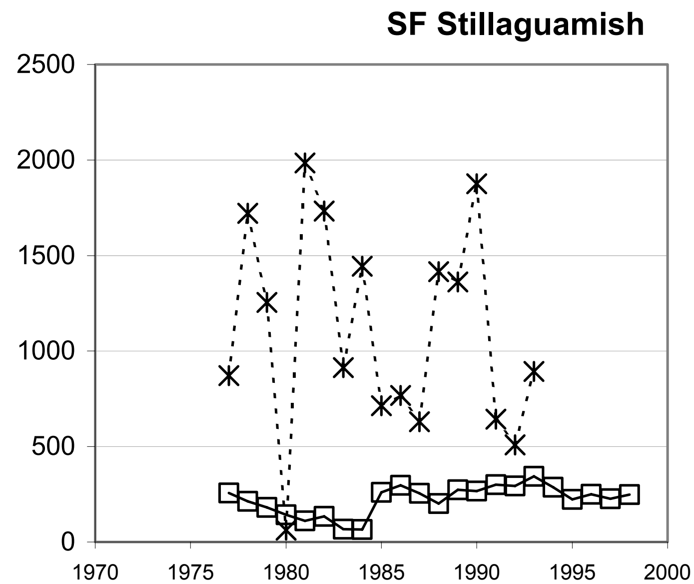
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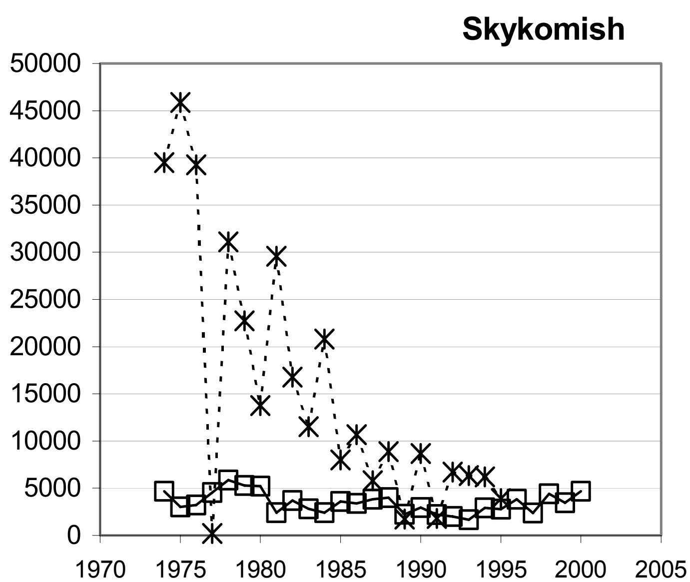
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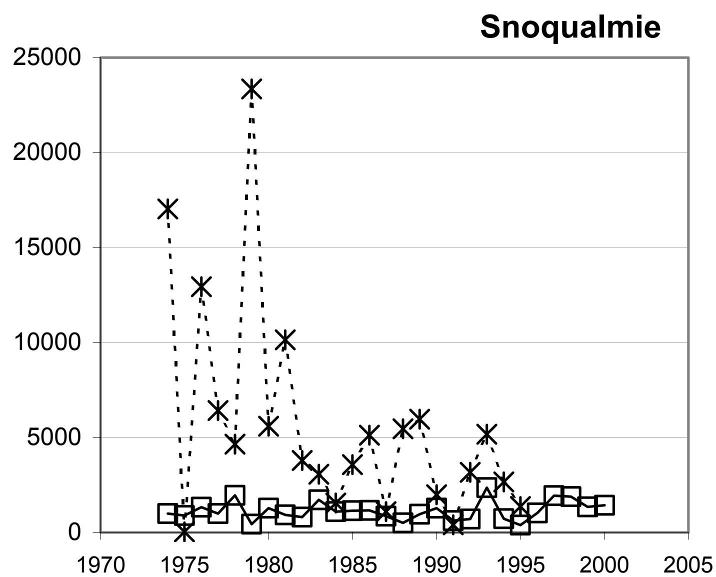
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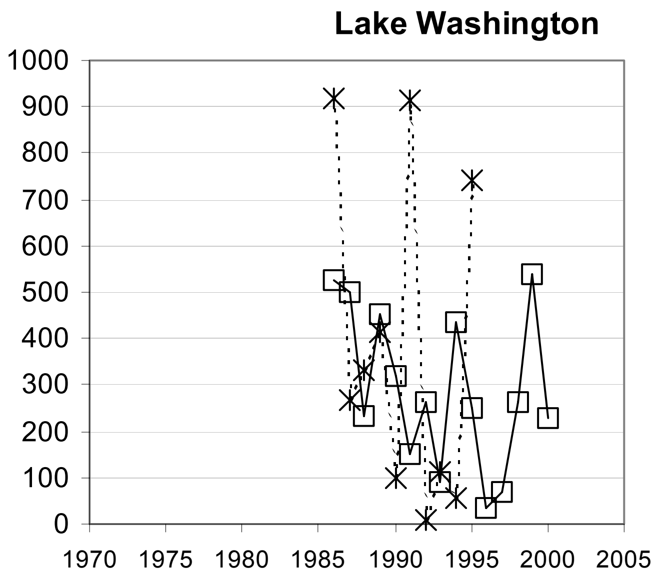
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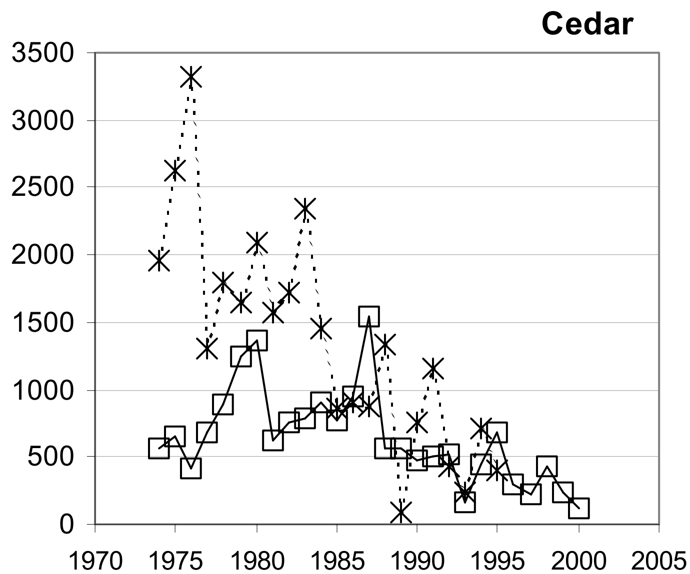
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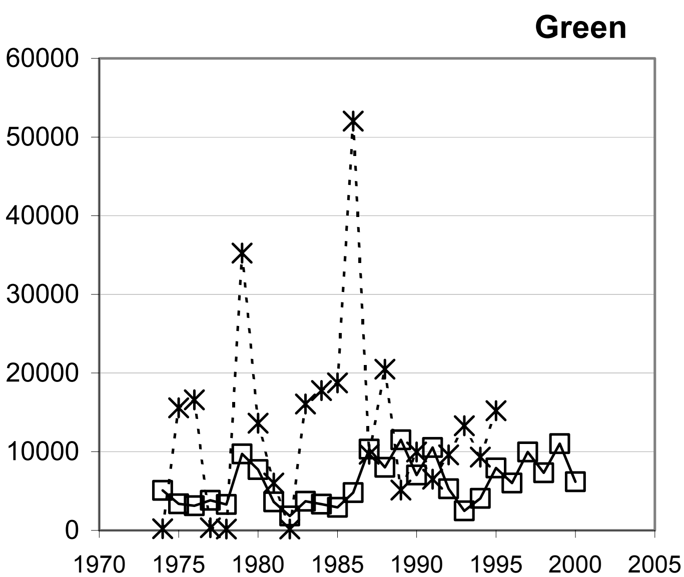
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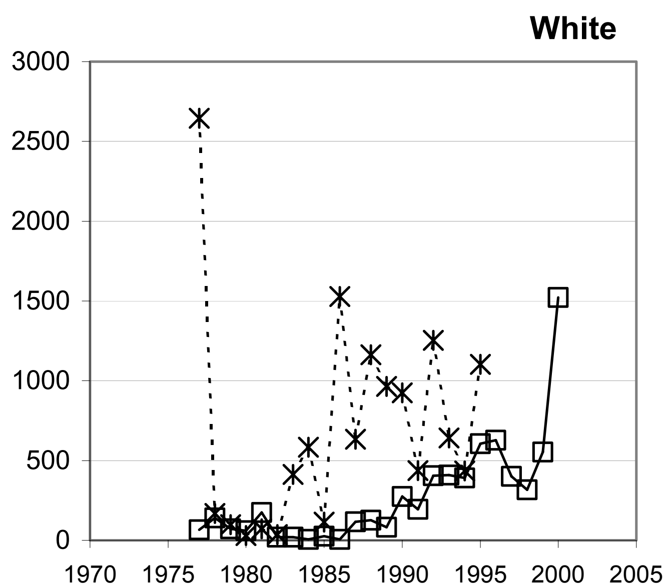
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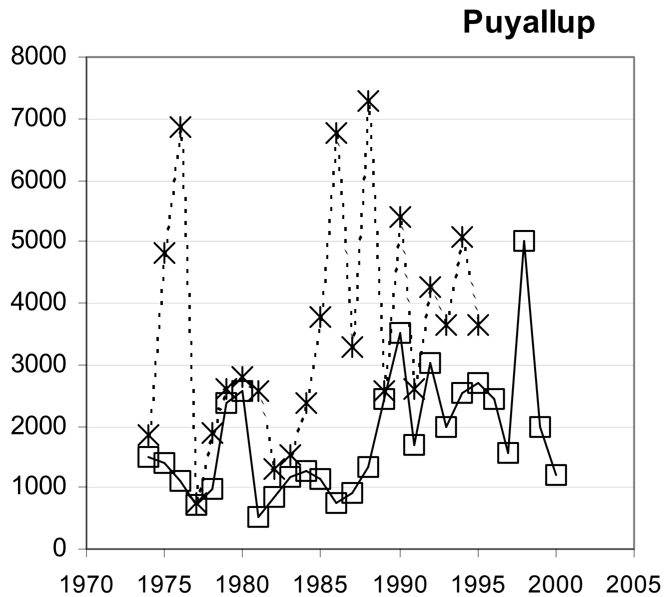
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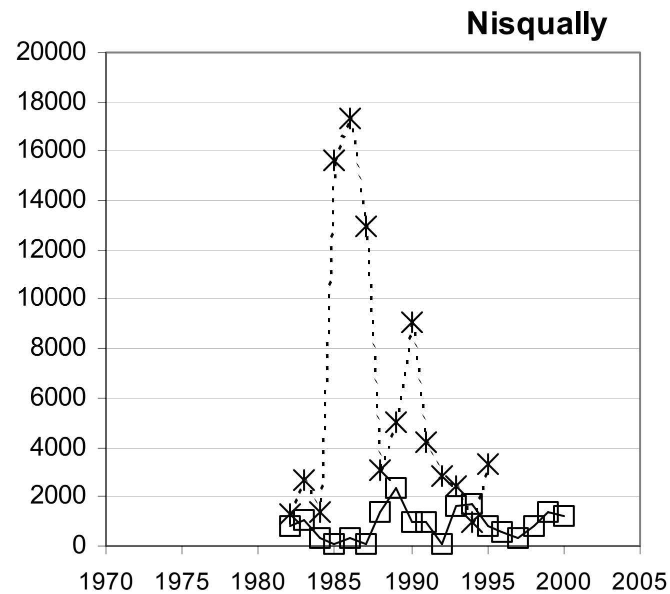
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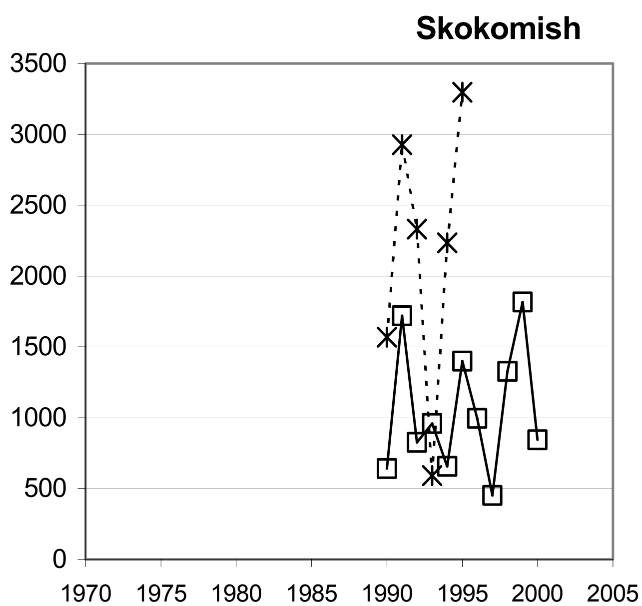
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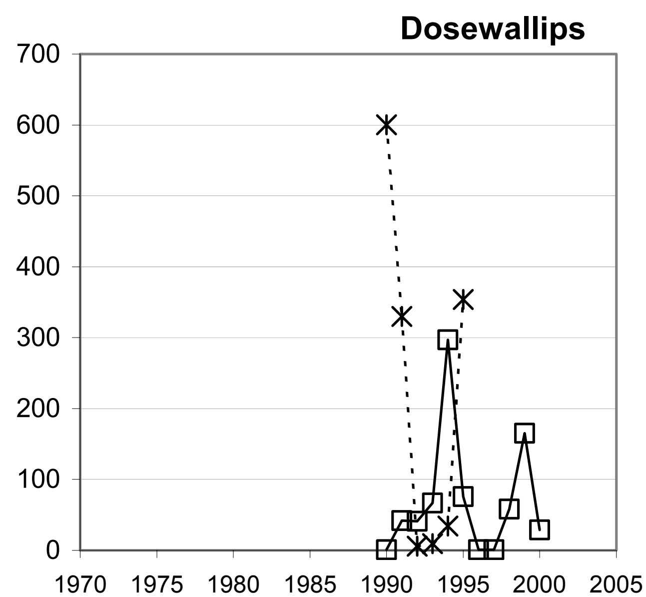
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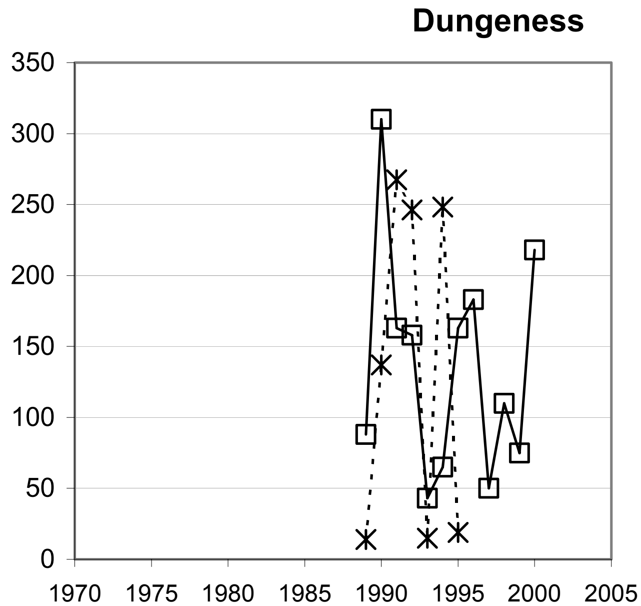
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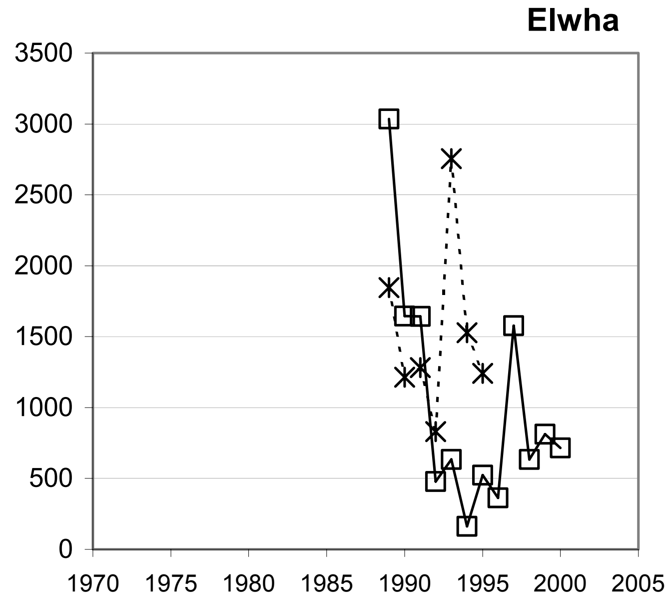
Elwha
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A.2.5 LOWER COLUMBIA CHINOOK

A.2.5.1 Previous BRT Conclusions

- A majority of the previous BRT concluded that the Lower Columbia River ESU is likely to become endangered in the foreseeable future. A minority felt that chinook salmon in this ESU were not presently in danger of extinction, nor were they likely to become so in the foreseeable future.
- LCR Chinook ESU was listed as Threatened in 1999.
- The previous BRT was concerned that there were very few naturally self-sustaining populations of native chinook salmon remaining in the lower Columbia River ESU.
- Naturally reproducing (but not necessarily self-sustaining) populations included the Lewis and Sandy River "bright" fall runs and the "tule" fall runs in the Clackamas, East Fork Lewis and Coweeman Rivers. These populations were identified as the only bright spots in the ESU.
- The few remaining populations of spring chinook salmon in the ESU were not considered to be naturally self-sustaining because of either small size, extensive hatchery influence, or both. The previous BRT felt that the dramatic declines and losses of spring-run chinook salmon populations in the Lower Columbia River ESU represented a serious reduction in life-history diversity in the region.
- The previous BRT felt that the presence of hatchery chinook salmon in this ESU posed an important threat to the persistence of the ESU and also obscured trends in abundance of native fish.
- The previous BRT noted that habitat degradation and loss due to extensive hydropower development projects, urbanization, logging and agriculture threatened the chinook salmon spawning and rearing habitat in the lower Columbia River.
- Currently listed as threatened.

A.2.5.2. New Data

New Data include:

- Spawner abundance through 2000 or 2001.
- new estimates of the fraction of hatchery spawners and harvest estimates.
- EDT based estimates of historical abundance.
- Information on recent hatchery releases.

A.2.5.3 New Updated Analyses

New analyses include

- Designation of relatively demographically independent populations.
- Recalculation of previous BRT metrics with additional years data.
- Estimates of median annual growth rate (λ) under different assumptions about the reproductive success of hatchery fish.
- Estimates of current and historically available kilometers of stream.

Historical population structure—As part of its effort to develop viability criteria for LCR chinook, The Willamette/Lower Columbia Technical Recovery Team (WLC-TRT) has identified historically demographically independent populations (Myers et al. 2002). Population boundaries are based on an application of Viable Salmonid Populations definition (McElhany et al. 2000). Myers et al. hypothesized that the ESU historically consisted of 20 fall-run populations ("tules"), two late fall-run populations ("brights") and nine spring-run populations for a total of 31 populations (Figures A.2.5.1 and A.2.5.2). The populations identified in Myers et al. are used as the units for the new analyses in this report.

The WLC-TRT partitioned LCR Chinook populations into a number of "strata" based on major life-history characteristics and ecological zones (McElhany et al. 2002). The WLC-TRT argues that a viable ESU would need a number of viable populations in each of these strata. The strata and associated populations are identified in Table 1.

Abundance and trends

Data sources for abundance time series and related data are in Appendix A.5.2. The recent abundance of natural origin spawners, recent fraction of hatchery origin spawners, and recent harvest rates for LCR Chinook populations are summarized in Table A.2.5.1. Natural origin fish had parents that spawned in the wild as opposed to hatchery origin fish whose parents were spawned in a hatchery. The abundances of natural origin spawners range from completely extirpated for most of the spring run populations to over 6,500 for the Lewis River bright population. The majority of the fall run tule populations have a substantial fraction of hatchery origin spawners in the spawning areas and are hypothesized to be sustained largely by hatchery production. Exceptions are the Coweeman and the Sandy fall run populations which have few hatchery fish spawning on the natural spawning areas. These populations have recent mean abundance estimates of 348 and 183 spawners respectively. The majority of the spring run populations have been extirpated largely as the result of dams blocking access to their high elevation habitat. The two bright chinook populations (i.e. Lewis and Sandy) have relatively high abundances, particularly the Lewis.

Where data are available, the abundance time series information for each of the populations is presented in Figures A.2.5.3-A.2.5.32. Three types of time series figures are presented. The first type of figure plots abundance against time (Figures A.2.5.3-A.2.5.19). Where possible, two lines are presented on the abundance figure, where one line is the total number of spawners (or total count at a dam) and the other line is the number of fish of natural origin. In many cases, data were not available to distinguish between natural and hatchery origin spawners, so only total spawner (or dam count) information is presented. This type of figure can give a sense of the levels of abundance, overall trend, patterns of variability, and the fraction of hatchery origin spawners. A high fraction of hatchery origin spawners indicates that the population may potentially be sustained by hatchery production and not the natural environment. It is important to note that estimates of the fraction of hatchery origin fish are highly uncertain since the hatchery marking rate for LCR fall chinook is generally only a few percent and expansion to population hatchery fraction is based on only a handful of recovered marked fish (unpublished analysis, McElhany, Rawding, and Sydor).

The second type of time series figure displays fish per mile data. For three populations of fall run chinook in Oregon watersheds total abundance estimates are not available, but fish per mile time series exists (Figures A.2.5.20-A.2.5.22). There are no estimates of the fraction of hatchery origin spanwers in these fish/mile time series, but may be high given the large number of hatchery fish released and the high fraction of hatchery origin spawners estimated in Washington watersheds directly across the Columbia River. The lack of information on hatchery fraction reduces the value of these time series for evaluating extinction risk.

The third type of time series figure presents the total number of spawners (natural and hatchery origin) and the number of preharvest recruits produced by those spawners against time (Figures A.2.5.23-A.2.5.32). Dividing the number of preharvest recruits by the number of spawners for the same time period would yield an estimate of the preharvest recruits per spawner. This type of figure requires harvest and age structure information and therefore could be produced for only a limited number of populations. This type of figure can indicate if there have been changes in preharvest recruitment and the degree to which harvest management has the potential to recover populations. If the preharvest recruitment line is consistently below the spawner line, it indicates that the population would not be replacing itself, even in the absence of all harvest.

Summary statistics on population trends and growth rate are presented in Tables A.2.5.2-A.2.5.3 and in Figures A.2.5.33-A.2.5.35. The methods for estimating trends and growth rate (λ) are described in the general method section. Because trends are only calculated for time series where the fraction of hatchery origin spawners is known, most of the long-term trend estimates use data starting in 1980, even though the abundance time series of total spawners may extend earlier than 1980. The majority of populations have a long-term trend less than one, indicating the population is in decline. In addition, there is a high probability for most populations that the true trend/growth rate is less than one (Table A.2.5.3). When growth rate is estimated, assuming that hatchery origin spawners have a reproductive success equal to that of natural origin spawners, all of the population have a negative growth rate except the Coweeman fall run, which had very few hatchery origin spawners (Figure A.2.5.35). The potential reasons for these declines have been cataloged in previous status reviews and include habitat degradation, deleterious hatchery practices, and climate-driven changes in marine survival.

The Lewis River bright population is considered the healthiest in the ESU. The population is significantly larger than any other population in the ESU, and, in fact, it is larger than any population of salmon in the Columbia Basin except the Hanford Reach chinook. The Lewis bright chinook harvest has been managed to an escapement target of 5,700 and this target has been met every year for which data are available (Figure A.2.5.16). The preharvest recruits have exceeded spanwers in all years for which data are available except one (Figure A.2.5.32). There is a hatchery program for Lewis River brights, but hatchery origin spawners have generally comprised less than 10% of the spawning population over the time series. These indicators all suggest a relatively healthy population. However, the long-term population trend estimate is negative (Figure A.2.5.33), and it is not clear the extent to which this reflects management decisions to harvest closer to the escapement goal as compared to declining productivity over the time series. The population is also geographically confined to a reach that is only a few kilometers in length and is immediately below Merwin Dam, where it is affected by the flow management of the hydrosystem. This limited spatial distribution is a potential risk factor.

EDT-based estimates of historical abundance—The Washington Department of Fish and Wildlife (WDFW) has conducted analyses of the LCR chinook populations using the Ecosystem Diagnosis and Treatment (EDT) model (in McElhany et al 2002). The EDT model attempts to predict fish population performance based on input information about reach-specific habitat attributes (http://www.olympus.net/community/dungenesswc/EDT-primer.pdf). WDFW populated this model with estimates of historical habitat condition which produced the estimates of average historical abundance shown in Table A.2.5.1. There is a great deal of unquantified uncertainty in the EDT historical abundance estimates that should be taken into consideration when interpreting these data. In addition, the habitat scenarios evaluated as "historical" may not reflect historical distributions, since some areas are historically accessible but currently blocked by large dams are omitted from the analyses and some areas that were historically inaccessible but recently passable because of human intervention are included. The EDT outputs are provided here to give a sense of the historical abundance of populations relative to each other and an estimate of the historical abundance relative to the current abundance.

Loss of habitat from barriers—An analysis was conducted by Steel and Sheer (2002) to assess the number of stream km historically and currently available to salmon populations in the LCR (Table A.2.5.4). Stream km usable by salmon are determined based on simple gradient cut offs and on the presence of impassable barriers. This approach will over estimate the number of usable stream km as it does not take into consideration habitat quality (other than gradient). However, the analysis does indicate that for some populations (particularly spring run) the number of stream habitat km currently accessible is greatly reduced from the historical condition.

A.2.5.4 New Hatchery/ESU Information

Recent Hatchery Releases

Updated information on chinook hatchery releases in the ESU is provided in Tables A.2.5.6- A.2.5.10.

Categorizations of Lower Columbia River hatchery stocks (SSHAG 2003) can be found in Appendix A.5.1.

A.2.5.5 Comparison with Previous Data

ESU Summary

The ESU exhibits three major life history types: fall run ("tules"), late fall run ("brights"), and spring run. The ESU spans three ecological zones: Coastal (rain driven hydrograph), Western Cascade (snow or glacial driven hydrograph), and Gorge (transitioning to drier interior Columbia ecological zones). The fall chinook populations are currently dominated by large scale hatchery production, relatively high harvest and extensive habitat degradation. The Lewis River late fall chinook population is the healthiest in the ESU and has a reasonable probability of being self-sustaining. The spring-run populations are largely extirpated as the result of dams which block access to their high elevation habitat. Abundances have largely declined since the last status review update (1998) and trend indicators for most all populations are negative, especially if hatchery fish are assumed to have a reproductive success equivalent to that of natural origin fish

Based on professional judgment synthesis of the updated information provided in this report plus the information contained in previous LCR status reviews, we have tentatively identified the number of historical and currently viable populations (Table A.2.5.5). This summary indicates that the ESU is substantially modified from historical population structure. Most tule fall chinook populations are potentially at risk of extinction and no populations of the spring run life-history type are currently considered self-sustaining. The Lewis River late fall bright population has the highest likelihood of being self-sustaining under current conditions.

Table A.2.5.1. Population structure and status information on LCR Chinook. The life history divisions are based on run timing and other correlated characters. The ecological zone is based on ecological community and hydro dynamic patterns. Every life-history/ecological zone combination constitutes a "stratum" (McElhany et al. 2002). The recent abundance is the geometric mean of natural origin spawners of the last five years of available data and the min-max are the lowest and highest five year geometric means in the time series. The data years are the data years used for the abundance min-max estimates, the extinction risk estimate and the trends (Figure 3). Longer time series may be available for spawners only (see figures) but hatchery fraction information was required to estimate means, extinction risk and trends. The fraction hatchery is the average percent of spawners of hatchery origin over the last four years. The harvest rate is the percent of adults harvested. The EDT estimate of historical abundance is based on analysis by WDFW of equilibrium abundance under historical habitat conditions. The quasi-extinction metric is the probability of declining from the current abundance to a four year average of 50 spawners/year within 100 years based on stochastic projection.

Life History	Ecological Zone	Population	Recent Abundance (min-max)	Data Years	Hatchery Fraction (%)	Harvest Rate (%)	EDT Estimate of Historical Abundance
Fall Run	coastal	Youngs Bay Fall Run		1970-2001			
		Grays River Fall Run	61 (33-627)	1980-2000	37	57	2,477
		Big Creek Fall Run		1970-2001			
		Elochoman River Fall Run	154 (78-349)	1980-2000	69	49	
		Clatskanie River Fall Run		1970-2001			
		Mill, Abernathy, Germany Fall Run	248 (248-1604)	1980-2000	47	40	
		Scappoose Creek Fall Run					
	cascade	Coweeman	348 (64-849)	1980-2000	0	31	4,973
		Lower Cowlitz River Fall Run	463 (20-1014)	1980-2000	67	24	53,956
		Upper Cowlitz River Fall Run	Extirpated				
		Toutle River Fall Run					25,392
		Kalama River Fall Run	848 (848-4511)	1980-2000	67	30	2,455
		Salmon Creek, Lewis River Fall Run	230 (213-360)				

		Clackamas River Fall Run					
		Washougal River Fall Run	903 (580-1840)	1980-2000	57	26	7,518
		Sandy River Fall Run	183	1988-2001	3		
	gorge	Lower Gorge Tributaries Fall Run					
		Upper Gorge Tributaries Fall Run	90 (11-390)	1980-2000	17		2,363
		Hood River Fall Run	<50				
		Big White Salmon Fall Run	98 (98-747)	1980-2000	22	65	
Late Fall (bright)	cascade	Sandy Late	504 (504-1213)	1984-2001	3		
		N.F. Lewis (bright)	6797 (6797-15903)	1980-2000	13	34	
Spring Run	cascade	Upper Cowlitz Spring Run	225 (169-334)	1980-2000	0		
		Cispus River Spring Run	Extirpated				
		Tilton River Spring Run	Extirpated				
		Toutle River Spring Run	Extirpated				2,901
		Kalama River Spring Run	138 (91-663)	1980-2000			4,178
		Lewis River Spring Run	320 (320-3287)	1980-2000			1,728
		Sandy River Spring Run	Extirpated				
	gorge	Big White Salmon Spring Run	Extirpated				
		Hood River Spring Run	Extirpated				
		Total	**11,720**				**107,941**
		Average			**31**	**40**	

Table A.2.5.2. Trend and growth rate for subset of Lower Columbia Chinook populations. 95% confidence intervals are in parentheses. The long term analysis used the entire data set (see table 2 for years). The criteria for the short term data set is defined in the methods section. In the "Hatchery = 0" columns, the hatchery fish are assumed to have zero reproductive success. In the "Hatchery = Wild" columns, hatchery fish are assumed to have the same relative reproductive success as natural origin fish.

Population	Long Term Analysis			Short Term Analysis		
	Trend (C.I.)	Lambda (C.I.)		Trend (C.I.)	Lambda (C.I.)	
		Hatchery = 0	Hatchery = Wild		Hatchery = 0	Hatchery = Wild
Grays River Fall Run	**0.882** (0.806-0.965)	**0.919** (0.718-1.177)	**0.824** (0.648-1.07)	**1.002** (0.759-1.323)	**0.95** (0.742-1.216)	**0.854** (0.664-1.097)
Elochoman River Fall Run	**1.012** (0.933-1.097)	**0.991** (0.774-1.269)	**0.776** (0.613-1.013)	**1.067** (0.86-1.323)	**1.015** (0.793-1.299)	**0.817** (0.636-1.05)
Mill, Abernathy, Germany Fall	**0.944** (0.885-1.007)	**0.919** (0.718-0.891)	**0.778** (0.588-0.971)	**0.874** (0.756-1.011)	**0.663** (1.087-0.912)	**0.704** (0.547-0.905)
Coweeman	**1.104** (1.022-1.192)	**1.131** (0.883-1.448)	**1.13** (0.86-1.421)	**0.953** (0.762-1.192)	**1.048** (0.818-1.341)	**1.048** (0.815-1.347)
Lower Cowlitz River Fall Run	**0.931** (0.799-1.085)	**0.998** (0.779-1.278)	**0.651** (0.533-0.882)	**1.467** (0.906-2.375)	**1.231** (0.962-1.577)	**0.777** (0.605-0.999)
Kalama River Fall Run	**0.951** (0.876-1.033)	**0.973** (0.76-1.246)	**0.821** (0.635-1.049)	**0.843** (0.669-1.062)	**0.94** (0.734-1.203)	**0.803** (0.625-1.032)
Salmon Creek, Lewis River Fall	**0.971** (0.94-1.003)	**0.972** (0.759-1.245)	**0.968** (0.761-1.257)	**0.983** (0.893-1.083)	**1.004** (0.784-1.286)	**1.004** (0.781-1.291)
Washougal River Fall Run	**1.028** (0.978-1.082)	**1.016** (0.793-1.3)	**0.81** (0.616-1.018)	**0.962** (0.845-1.094)	**0.959** (0.749-1.227)	**0.75** (0.583-0.964)
Upper Gorge Tributaries Fall	**0.876** (0.793-0.968)	**0.942** (0.736-1.206)	**0.94** (0.792-1.308)	**1.103** (0.802-1.516)	**1.239** (0.967-1.586)	**1.233** (0.959-1.585)
Big White Salmon Fall Run	**0.905** (0.849-0.964)	**0.89** (0.695-1.139)	**0.879** (0.679-1.122)	**0.94** (0.767-1.154)	**0.883** (0.69-1.131)	**0.858** (0.667-1.102)
Sandy Late	**.946** (0.883-1.014)	**.943** (0.836-1.063)	**.935** (0.829-1.054)	**0.915** (0.796-1.052)	**0.919** (0.815-1.037)	**0.912** (0.809-1.028)
N.F. Lewis (bright)	**0.962** (0.932-0.993)	**0.957** (0.747-1.225)	**0.937** (0.725-1.198)	**0.927** (0.842-1.022)	**0.937** (0.732-1.2)	**0.918** (0.714-1.181)

Upper Cowlitz Spring Run	**0.987** (0.924-1.054)	**0.957** (0.755-1.259)	**0.975** (0.76-1.271)	**0.989** (0.818-1.196)	**1.002** (0.776-1.294)	**1.002** (0.775-1.096)
Kalama River Spring Run	**0.933** (0.812-1.072)	**0.872** (0.675-1.126)	**0.872** (0.718-1.201)	**1.097** (0.848-1.419)	**1.097** (0.85-1.417)	**1.097** (0.849-1.419)
Lewis River Spring Run	**0.935** (0.867-1.009)	**0.949** (0.735-1.226)	**0.947** (0.695-1.163)	**0.792** (0.72-0.87)	**0.789** (0.611-1.019)	**0.784** (0.66-1.014)

Table A.2.5.3. Probability the trend or growth rate is less than one. In the “Hatchery = 0” columns, the hatchery fish are assumed to have zero reproductive success. In the “Hatchery = Wild” columns, hatchery fish are assumed to have the same relative reproductive success as natural origin fish.

Population	Long Term Analysis			Short Term Analysis		
	Trend	Lambda		Trend	Lambda	
		Hatchery = 0	Hatchery = Wild		Hatchery = 0	Hatchery = Wild
Grays River Fall Run	0.996	0.789	0.955	0.493	0.594	0.765
Elochoman River Fall Run	0.380	0.531	0.972	0.258	0.467	0.826
Mill, Abernathy, Germany Fall	0.961	0.849	1.000	0.967	0.912	0.990
Coweeman	0.007	0.113	0.160	0.680	0.395	0.395
Lower Cowlitz River Fall Run	0.830	0.507	0.998	0.053	0.165	0.886
Kalama River Fall Run	0.890	0.606	0.970	0.936	0.692	0.936
Salmon Creek, Lewis River Fall	0.965	0.765	0.712	0.651	0.474	0.474
Washougal River Fall Run	0.130	0.391	1.000	0.746	0.639	0.987
Upper Gorge Tributaries Fall	0.994	0.649	0.455	0.249	0.177	0.184
Big White Salmon Fall Run	0.998	0.888	0.925	0.743	0.778	0.837
Sandy Late	0.944	0.833	0.863	0.906	0.827	0.849
N.F. Lewis (bright)	0.991	0.847	0.964	0.944	0.877	0.932
Upper Cowlitz Spring Run	0.659	0.624	0.588	0.553	0.491	0.496
Kalama River Spring Run	0.847	0.866	0.729	0.216	0.303	0.303
Lewis River Spring Run	0.960	0.731	0.890	1.000	0.997	0.997

Table A.2.5.4. Loss of habitat from barriers. The potential current habitat is the kilometers of stream below all currently impassible barriers between a gradient of 0.5% and 4%. . The potential historical habitat is the kilometers of stream below historically impassible barriers between a gradient of 0.5% and 4%. The current to historical habitat ratio is the percent of the historical habitat that is currently available.

Population	Potential Current Habitat (km)	Potential Historical Habitat (km)	Current to Historical Habitat Ratio (%)
Youngs Bay Fall Run	178	195	91
Grays River Fall Run	133	133	100
Big Creek Fall Run	92	129	71
Elochoman River Fall Run	85	116	74
Clatskanie River Fall Run	159	159	100
Mill, Abernathy, Germany Fall Run	117	123	96
Scappoose Creek Fall Run	122	157	78
Coweeman	61	71	86
Lower Cowlitz River Fall Run	418	919	45
Upper Cowlitz River Fall Run			
Toutle River Fall Run	217	313	69
Kalama River Fall Run	78	83	94
Salmon Creek, Lewis River Fall Run	438	598	73
Clackamas River Fall Run	568	613	93
Washougal River Fall Run	84	164	51
Sandy River Fall Run	227	286	79
Lower Gorge Tributaries Fall Run	34	35	99
Upper Gorge Tributaries Fall Run	23	27	84
Hood River	35	35	100

Fall Run			
Big White Salmon Fall Run	0	71	0
Sandy Late	217	225	96
N.F. Lewis (bright)	87	166	52
Upper Cowlitz Spring Run	4	276	1
Cispus River Spring Run	0	76	0
Tilton River Spring Run	0	93	0
Toutle River Spring Run	217	313	69
Kalama River Spring Run	78	83	94
Lewis River Spring Run	87	365	24
Sandy River Spring Run	167	218	77
Big White Salmon Spring Run	0	232	0
Hood River Spring Run	150	150	99
Total	**4,075**	**6,421**	**63**
Average			

Table A.2.5.5. Number of populations in the ESU of each life history type. Populations with "some current natural production" have some natural origin recruits present but are not necessarily considered self-sustaining ("viable"). The determination of the number of populations potentially currently viable is based on professional judgment analysis of abundance, growth rate/trends and other extinction risk metrics.

	Life-History Type			
	Fall	**Late-Fall ("bright")**	**Spring**	**Total**
Historical	20	2	9	31
Some current natural production	17-19	2	2	21-23
Currently "viable" populations	0-1	1-2	0	1-3

Table A.2.5.6. Washington Fall LCR Chinook hatchery releases.

Watershed	Years	Hatchery	Stock	Release Site	Total
Chinook River	1990-1994	Sea Resources	Chinook River	Chinook R	2,598,400
	1990	Sea Resources	Washougal	Chinook R	629,500
	1997-2000	Sea Resources	Chinook River	Chinook R	820,627
Deep River	1993	Lower Columbia	Kalama Falls	Deep R	49,400
Grays River	1990-1994	Grays River	Grays River	Grays R	2,767,900
	1991, 1993	Grays River	Kalama Falls	Grays R	1,332,380
	1992	Grays River	Spring Creek	Grays R	1,107,000
	1995-1997	Grays River	Kalama	Grays R	764,550
	1996, 1997	Grays River	Washougal	Grays R	1,745,500
Elochomin River	1990-1994	Elokomin	Elochomin	Elochomin R	17,809,719
	1991	Elokomin	Kalama Falls	Elochomin R	1,046,700
	1995	Beaver Creek	Abernathy	Beaver Cr	377,252
	1997	Beaver Creek	Big Creek	Beaver Cr	1,096,198
	1996-1999	Beaver Creek	Elochoman	Elochoman R	2,081,670
	1995	Beaver Creek	Kalama	Beaver Cr	760,039
	1995-2001	Elochoman	Elochoman	Elochoman R	15,280,038
	1999	Elochoman	Grays River	Elochoman R	174,500
	1997-1998	Elochoman	Washougal	Elochoman R	1,633,200
L Columbia River	1996-1998	Cathlamet Ffa	Washougal	Columbia R	1,132,500
Cowlitz River	1990-1994	Cowlitz	Cowlitz	Cowlitz R	28,757,600
	1995-2001	Cowlitz	Cowlitz	Cowlitz R	42,322,920
Toutle River	1990-1993	Toutle	Kalama Falls	Green R	5,718,000
	1991-1993	Toutle	Toutle	Green R	2,941,000
	1994	Toutle	Tule	Green R	2,044,500
	1990-1993	Toutle	Washougal	Green R	2,693,400
	2000	North Toutle	Elochoman	Green R	618,266
	1996	North Toutle	Kalama	Green R	1,588,937
	1996-2001	North Toutle	Toutle	Green R	10,584,543
	1996	North Toutle	Washougal	Green R	633,414
Kalama River	1991-1994	Lower Kalama	Kalama	Kalama	10,701,203
	1990-1994	Kalama Falls	Kalama Falls	Kalama	17,600,800
	1996-2001	Fallert Cr	Kalama	Fallert Cr	13,998,602
	1995-2001	Kalama Falls	Kalama	Kalama R	20,198,653
Washougal River	1994	Washougal	Kalama Falls	Washougal R	2,443,100
	1992	Washougal	Spring Creek	Washougal R	1,409,300
	1991-1994	Washougal	Washougal	Washougal R	27,002,103
	2000	Washougal	Elochoman	Washougal R	1,312,680
	1995-2001	Washougal	Washougal	Washougal R	32,878,694
Spring Creek	1992	Ringold	L White Salmon	Spring Creek	82,511

Table A.2.5.7. Oregon Fall LCR Chinook hatchery releases.

Watershed	Years	Hatchery	Stock	Release Site	Total
Youngs Bay	1991-1995	Astoria H.S.	Big Creek	Youngs Bay	15,500
	1991-1994	Cedc	Rogue River	Youngs Bay	394,382
	1991, 1992	Step	Big Creek	Youngs Bay	13,758
	1992, 1993	Step	Klaskanine	Youngs Bay	15,700
	1996-1998	Step	Big Creek	Youngs Bay	63,050
	1997, 1998	Step	Unknown	Youngs Bay	16,500
	1995-2002	Youngs Bay	Rogue River	Youngs Bay	4,248,147
	1996-1998	Youngs Bay	Urb	Youngs Bay	828,884
L Columbia River	1991	Step	Unknown	L Columbia River	25,000
	1996, 1997	Tongue Pt	Rogue River	Tongue Point	54,274
	1996, 1997	Tongue Pt	Urb	Tongue Point	299,715
	1995-1997	Blind Slough	Rogue River	Blind Slough	54,793
Skipanon River	1992-1993	Step	Klaskanine	Skipanon R	3,550
	1996-1999	Step	Big Creek	Skipanon R	15,193
Plympton Creek	1991	Big Creek	Big Creek	Plympton Cr	50,278
Big Creek	1991-1994	Big Creek	Big Creek	Big Cr	34,675,446
	1991-1994	Big Creek	Rogue River	Big Cr	2,798,710
	1993	Big Creek	Kalama Falls	Big Cr	886,471
	1995-2002	Big Creek	Big Creek	Big Cr	40,633,091
	1995-1996	Big Creek	Rogue River	Big Cr	1,530,550
Klaskanine River	1995	Cedc	Rogue River	Klaskanine R	15,758
	1996-1999	Klaskanine	Rogue River	Klaskanine R	3,694,245
Wahkeena Pd	1991-1993	Bonneville	Urb	Columbia River	1,183,764
Johnson Cr	1994, 1995	Step	Tanner Creek	Johnson Creek	99,008
Tanner Cr	1991	Bonneville	Big Creek	Tanner Creek	2,580,763
	1991-1994	Bonneville	Tanner Creek	Tanner Creek	32,862,338
	1991	Bonneville	Wa Tule	Tanner Creek	1,534,122
	1991-1994	Bonneville	Urb	Tanner Creek	26,877,822
	1993	Bonneville	Kalama Falls	Tanner Creek	1,505,421
	1995-1996	Bonneville	Tanner Creek	Tanner Creek	15,369,642
	1995-1996	Bonneville	Wa Tule	Tanner Creek	10,922,745
	1995-2002	Bonneville	Urb	Tanner Creek	43,729,497
	2000-2001	Bonneville	Wa Urb	Tanner Cr	328,426

Table A.2.5.8. Washington LCR spring Chinook hatchery releases.

Watershed	Years	Hatchery	Stock	Release Site	Total
Deep River	1999-2001	Deep R	Cowlitz	Deep R	255,657
Abernathy Creek	1991-1996	Abernathy Nfh	Abernathy Cr	Abernathy Cr	6,853,504
	1997-1999	Abernathy Nfh	Abernathy Cr	Abernathy Cr	1,223,647
Cowlitz River	1990-1994	Cowlitz	Cowlitz	Cowlitz R	9,016,451
	1992-1994	Friends Of Cow	Cowlitz	Cowlitz R	115,800
	1995-2001	Cowlitz	Cowlitz	Cowlitz R	8,870,002
	1995, 1997	Cowlitz	Cowlitz	Tilton R	3,074 Adults
	1996, 1999	Friends Of Cowlitz	Cowlitz	Cowlitz R	53,800
Toutle River	1991, 1993	Toutle	Cowlitz	Green R	641,382
	1995	North Toutle	Toutle	Green R	1,412,100
	1995	North Toutle	Washougal	Green R	1,086,100
	1995-2001	North Toutle	Cowlitz	Green R	766,740
Lewis River	1990-1993	Speelyai	Lewis	Lewis R	1,229,262
	1994	Lewis River	Kalama	N F Lewis R	975,700
	1991, 1992	Lewis River	Lewis	Lewis R	1,885,900
	1990-1994	Lewis River	N F Lewis	N F Lewis R	1,801,800
	1996	Fish First Np	Lewis	Lewis R	55,872
	1997-2000	Fish First Np	Lewis	Lewis R	570,857
	1996, 1998	Lewis River	Lewis	Lewis R	2,074,841
	2001	Lewis River	Lewis	Lewis R	34 Adults
	1995-2001	Lewis River	Lewis	Lewis R	4,692,781
	2001	Speelyai	Lewis	Lewis R	566,373
Kalama River	1990-1994	Lower Kalama	Kalama	Hatchery Cr	2,455,252
	1995-2001	Fallert Cr	Kalama	Fallert Cr	2,129,550
	1998, 2000	Fallert Cr	Lewis	Fallert Cr	615,463
	1999	Gobar Pond	Kalama	Gobar Cr	87,500
	1997, 2001	Kalama Falls	Kalama	Gobar Cr	332,281
Spring Creek	1993	Ringold	Carson	Spring Cr	68,900
	1993	Ringold	Kalama	Spring Cr	462,700
	1990	Ringold	Klickitat	Spring Cr	40,264
	1994	Ringold	L White Salm	Spring Cr	336,268
	1993-1994	Ringold	Ringold	Spring Cr	596,274
	1992-1994	Ringold	Wind River	Spring Cr	2,250,000
Wind River	1991-1996	Carson Nfh	Carson	Wind R	13,350,658
	1997-2001	Carson Nfh	Carson	Wind R	7,096,346
L White Salmon River	1991-1994	L White Salmon Nfh	Spring Creek	L White Salmon R	2,757,539
	1992	Willard Nfh	Carson	L White Salmon R	869,952

	1991-1994	L White Salmon Nfh	Carson	L White Salmon R	4,780,148
	1997	L White Salmon Nfh	Carson	L White Salmon R	2,835,741
	1998-2001	L White Salmon Nfh	L White Salmon	L White Salmon R	4,272,833
	1998-2001	L White Salmon Nfh	Urb-Mixed	L White Salmon R	8,057,188
Drano Lake		Abernathy Nfh	Spring Creek	Dranos Lake	40,756
Spring Creek	1991	Spring Creek Nfh	Urb-Bonn Dam	Spring Cr	14,348,604
	1991	Spring Creek Nfh	Clackamas	Spring Cr	3,292,304
	1992-1996	Spring Creek Nfh	Spring Creek	Spring Cr	89,083,822
	1997-2001	Spring Creek Nfh	Spring Creek	Spring Cr	70,435,986
B White Salmon River	1991-1996	Big White Salmon Nfh	Carson	B White Salmon R	3,581,536
	1997-1999	Big White Salmon Nfh	Carson	B White Salmon R	2,795,464
	2001	Big White Salmon Nfh	Methow	B White Salmon R	1,238,764
	1997	Spring Creek Nfh	Carson	B White Salmon R	543,270
Deep River	1999-2001	Deep R	Cowlitz	Deep R	255,657
Abernathy Creek	1991-1996	Abernathy Nfh	Abernathy Cr	Abernathy Cr	6,853,504
	1997-1999	Abernathy Nfh	Abernathy Cr	Abernathy Cr	1,223,647
Cowlitz River	1990-1994	Cowlitz	Cowlitz	Cowlitz R	9,016,451
	1992-1994	Friends Of Cow	Cowlitz	Cowlitz R	115,800
	1995-2001	Cowlitz	Cowlitz	Cowlitz R	8,870,002
	1995, 1997	Cowlitz	Cowlitz	Tilton R	3,074 Adults
	1996, 1999	Friends Of Cowlitz	Cowlitz	Cowlitz R	53,800
Toutle River	1991, 1993	Toutle	Cowlitz	Green R	641,382
	1995	North Toutle	Toutle	Green R	1,412,100
	1995	North Toutle	Washougal	Green R	1,086,100
	1995-2001	North Toutle	Cowlitz	Green R	766,740
Lewis River	1990-1993	Speelyai	Lewis	Lewis R	1,229,262
	1994	Lewis River	Kalama	N F Lewis R	975,700
	1991, 1992	Lewis River	Lewis	Lewis R	1,885,900
	1990-1994	Lewis River	N F Lewis	N F Lewis R	1,801,800
	1996	Fish First Np	Lewis	Lewis R	55,872
	1997-2000	Fish First Np	Lewis	Lewis R	570,857
	1996, 1998	Lewis River	Lewis	Lewis R	2,074,841
	2001	Lewis River	Lewis	Lewis R	34 Adults

	1995-2001	Lewis River	Lewis	Lewis R	4,692,781
	2001	Speelyai	Lewis	Lewis R	566,373
Kalama River	1990-1994	Lower Kalama	Kalama	Hatchery Cr	2,455,252
	1995-2001	Fallert Cr	Kalama	Fallert Cr	2,129,550
	1998, 2000	Fallert Cr	Lewis	Fallert Cr	615,463
	1999	Gobar Pond	Kalama	Gobar Cr	87,500
	1997, 2001	Kalama Falls	Kalama	Gobar Cr	332,281
Spring Creek	1993	Ringold	Carson	Spring Cr	68,900
	1993	Ringold	Kalama	Spring Cr	462,700
	1990	Ringold	Klickitat	Spring Cr	40,264
	1994	Ringold	L White Salm	Spring Cr	336,268
	1993-1994	Ringold	Ringold	Spring Cr	596,274
	1992-1994	Ringold	Wind River	Spring Cr	2,250,000
Wind River	1991-1996	Carson Nfh	Carson	Wind R	13,350,658
	1997-2001	Carson Nfh	Carson	Wind R	7,096,346
L White Salmon River	1991-1994	L White Salmon Nfh	Spring Creek	L White Salmon R	2,757,539
	1992	Willard Nfh	Carson	L White Salmon R	869,952
	1991-1994	L White Salmon Nfh	Carson	L White Salmon R	4,780,148
	1997	L White Salmon Nfh	Carson	L White Salmon R	2,835,741
	1998-2001	L White Salmon Nfh	L White Salmon	L White Salmon R	4,272,833
	1998-2001	L White Salmon Nfh	Urb-Mixed	L White Salmon R	8,057,188
Drano Lake		Abernathy Nfh	Spring Creek	Dranos Lake	40,756
Spring Creek	1991	Spring Creek Nfh	Urb-Bonn Dam	Spring Cr	14,348,604
	1991	Spring Creek Nfh	Clackamas	Spring Cr	3,292,304
	1992-1996	Spring Creek Nfh	Spring Creek	Spring Cr	89,083,822
	1997-2001	Spring Creek Nfh	Spring Creek	Spring Cr	70,435,986
B White Salmon River	1991-1996	Big White Salmon Nfh	Carson	B White Salmon R	3,581,536
	1997-1999	Big White Salmon Nfh	Carson	B White Salmon R	2,795,464
	2001	Big White Salmon Nfh	Methow	B White Salmon R	1,238,764
	1997	Spring Creek Nfh	Carson	B White Salmon R	543,270

Table A.2.5.9. Oregon LCR spring Chinook hatchery releases.

Watershed	Years	Hatchery	Stock	Release Site	Total
Youngs Bay	1991-1992	Cedc	Clackamas	Youngs Bay	242,534
	1994	Cedc	N Santiam	Youngs Bay	301,361
	1992	Cedc	Willamette	Youngs Bay	301,786
	1996	Youngs Bay	Clackamas	Youngs Bay	97,945
	1995-1999	Youngs Bay	Willamette	Youngs Bay	3,114,060
	1996	Youngs Bay	S Santiam	Youngs Bay	276,493
L Columbia River	1996	Blind Slough	S Santiam	Blind Slough	199,389
	1995-2002	Blind Slough	Willamette	Blind Slough	1,457,655
	1996	Tongue Pt	S Santiam	Tongue Point	242,319
	1997-2000	Tongue Pt	Willamette	Tongue Point	1,029,850
Klaskanine River	1991	Cedc	Clackamas	Sf Klaskanine R	119,627
	1994	Cedc	N Santiam	Sf Klaskanine R	109,974
	1992, 1997	Cedc	Willamette	Sf Klaskanine R	238,316
	1996	Cedc	S Santiam	Sf Klaskanine R	76,618
Multnomah Channel	1997-1998	Step	Mckenzie	L Willamette R	123,134
Sandy R	1991-1994	Clackamas	Clackamas	Sandy R	1,316,973
	1991-1993	Clackamas	Clackamas	Salmon R	594,656
	1995-2002	Clackamas	Clackamas	Sandy R	3,539,458
Hood River	1991-1992	Bonneville	Lookingglass	Hood R	288,727
	1993-1995	Bonneville	Deschutes	Hood R	245,209
	1996-2001	Various (3)	Deschutes	Hood R	677,652
	2000-2002	Parkdale	Wild Origin	Hood R	101,883
	2000	Parkdale	Hood River	Hood R	4,126

Table A.2.5.10. Washington up river bright hatchery releases. (Note "up river bright" chinook are not in the LCR chinook ESU.

Watershed	Years	Hatchery	Stock	Release Site	Total
L White Salmon River	1991-1993	L White Salmon Nfh	Urb-Eggbank	L White Salmon R	8,758,842
	1994-1996	L White Salmon Nfh	Carson	L White Salmon R	8,453,502
	1994-1996	L White Salmon Nfh	Carson	L White Salmon R	1,225Adults
Spring Creek	1994	Ringold	Urb-Bonn Dam	Spring Cr	4,217,491

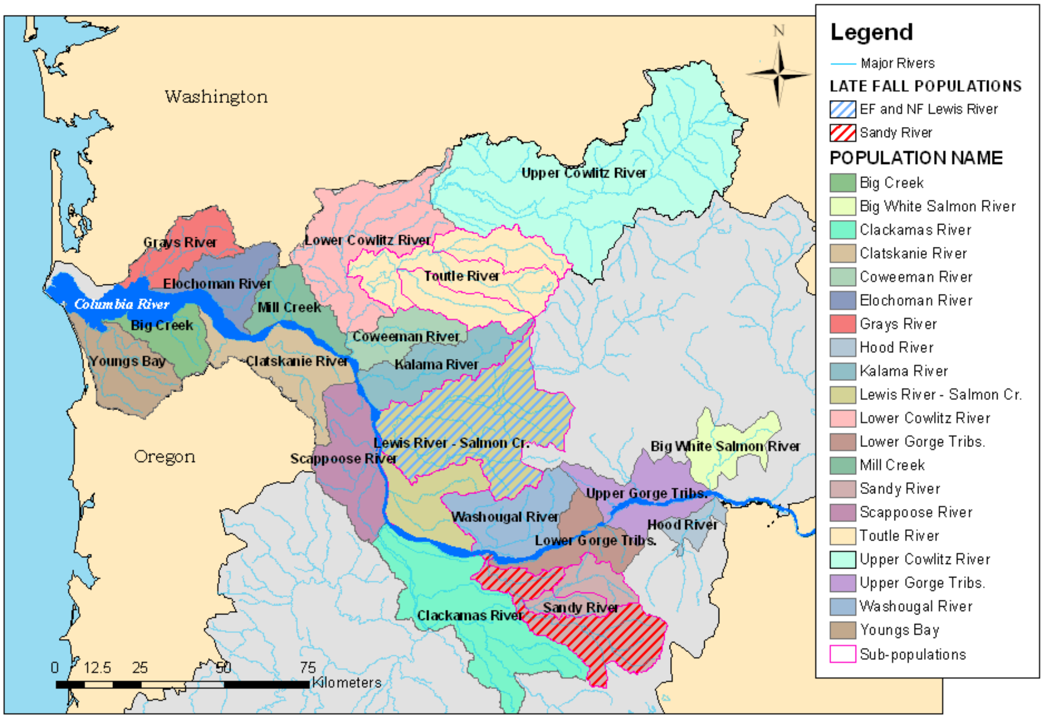


Figure A.2.5.1. Historical independent LCR early and late fall Chinook populations (Myers et al. 2002).

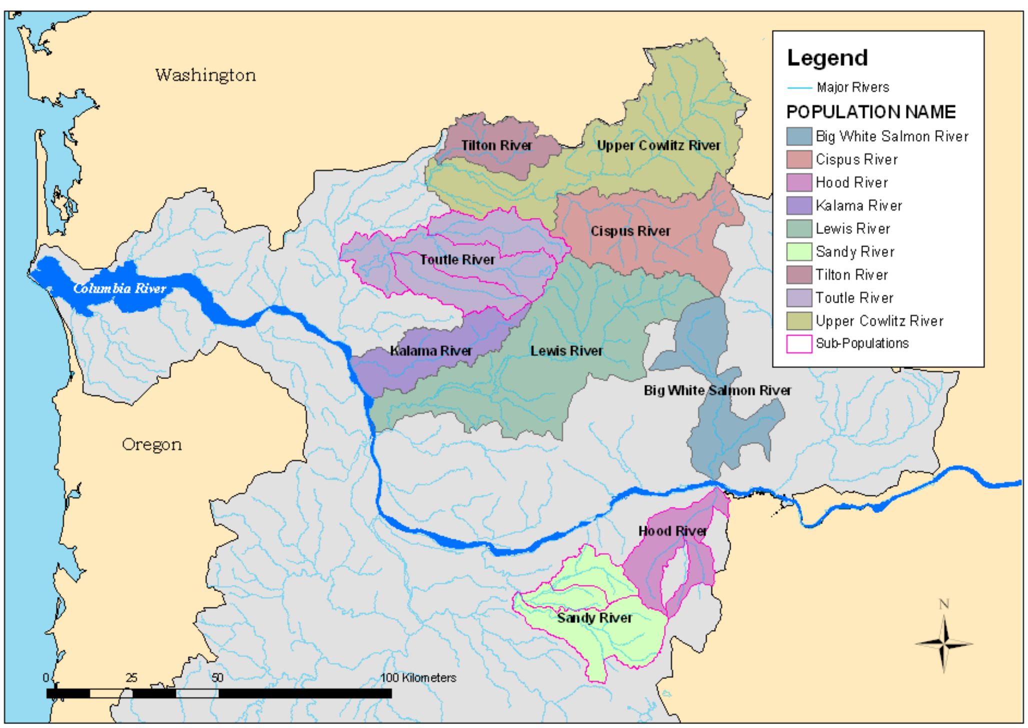


Figure A.2.5.2. Historical independent LCR spring Chinook populations (Myers et al. 2002).

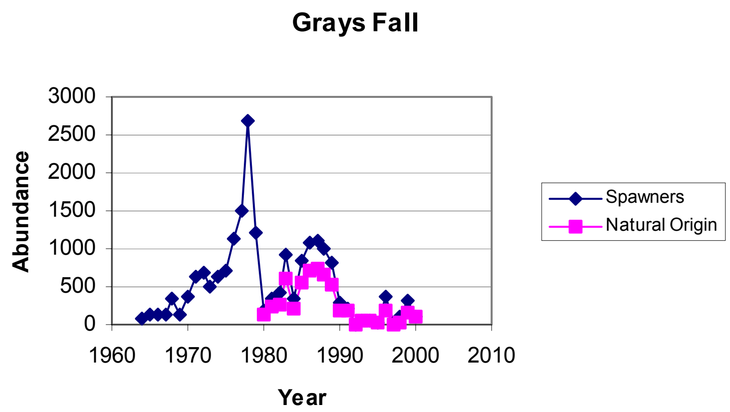


Figure A.2.5.3. Grays River fall Chinook population abundance.

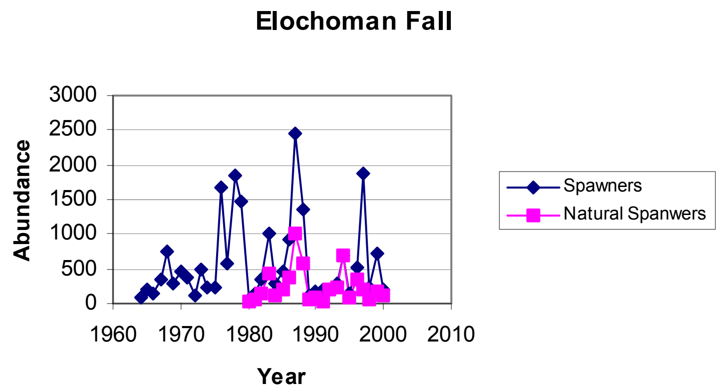


Figure A.2.5.4. Elochoman fall chinook population abundance.

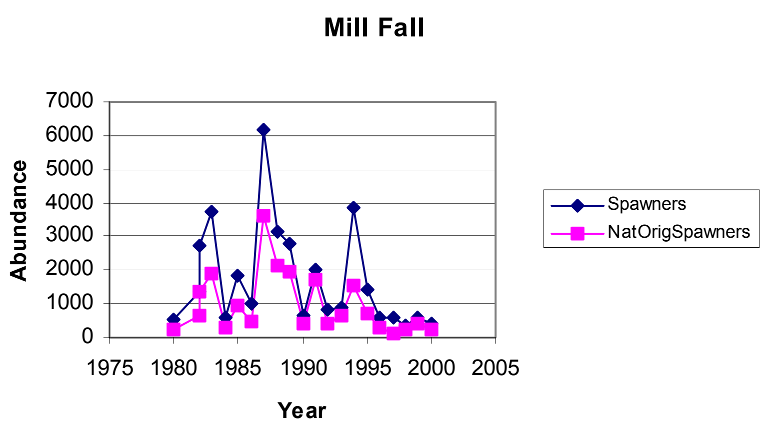


Figure A.2.5.5. Mill, Germany Abernathy fall chinook population abundance.

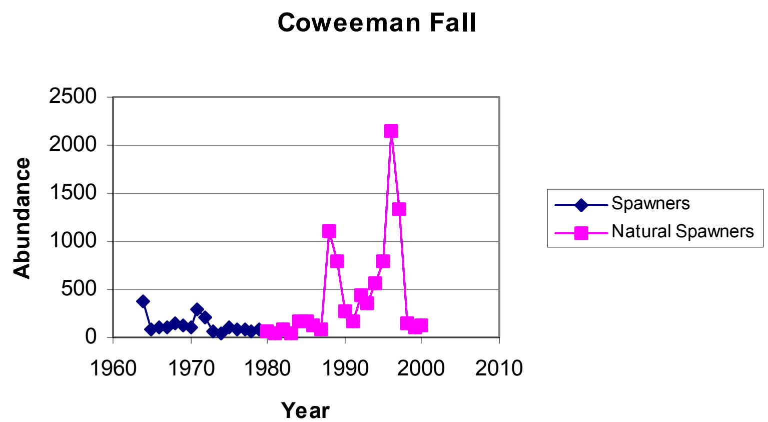


Figure A.2.5.6. Coweeman fall chinook population abundance.

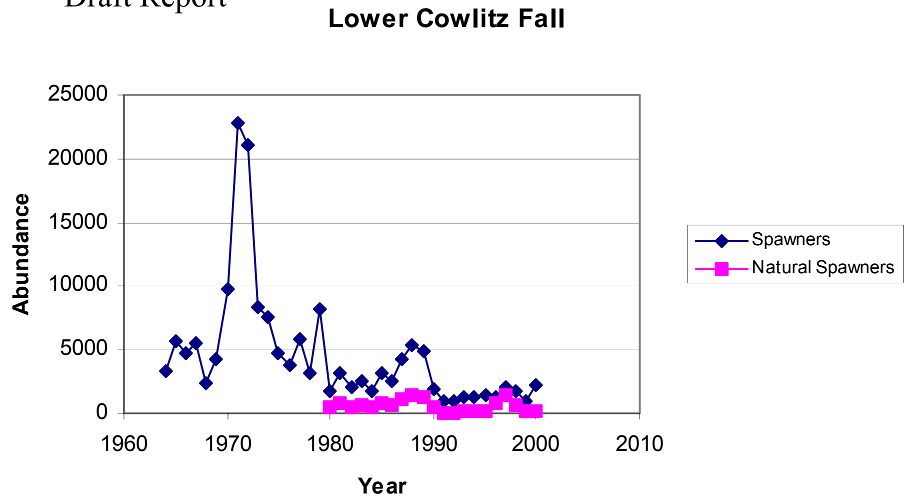


Figure A.2.5.7. Lower Cowlitz fall chinook population abundance.

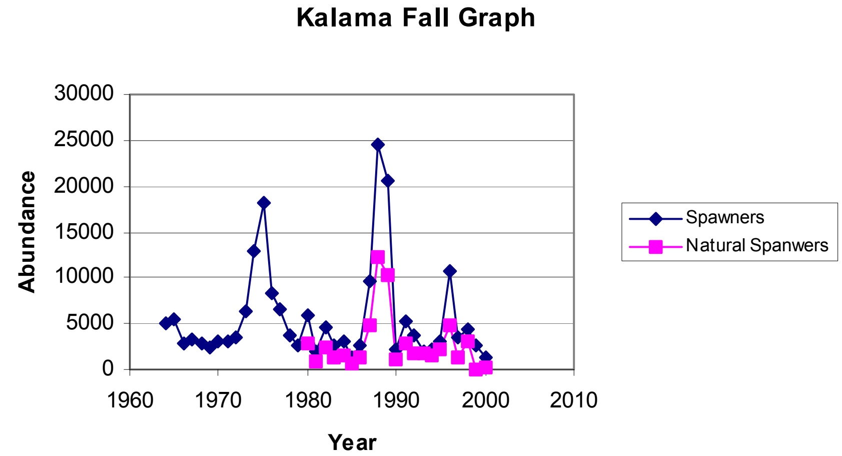


Figure A.2.5.8. Kalama fall chinook population abundance.

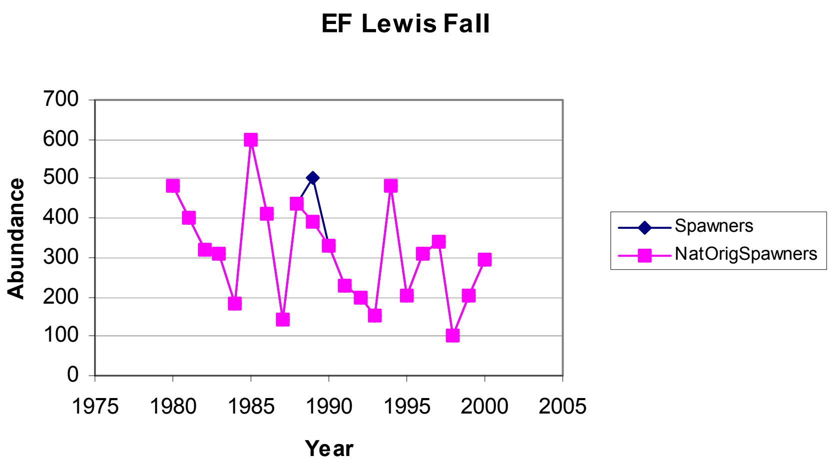


Figure A.2.5.9. E.F Lewis fall chinook abundance. The E.F. Lewis is a component of the Salmon/Lewis fall Chinook population.

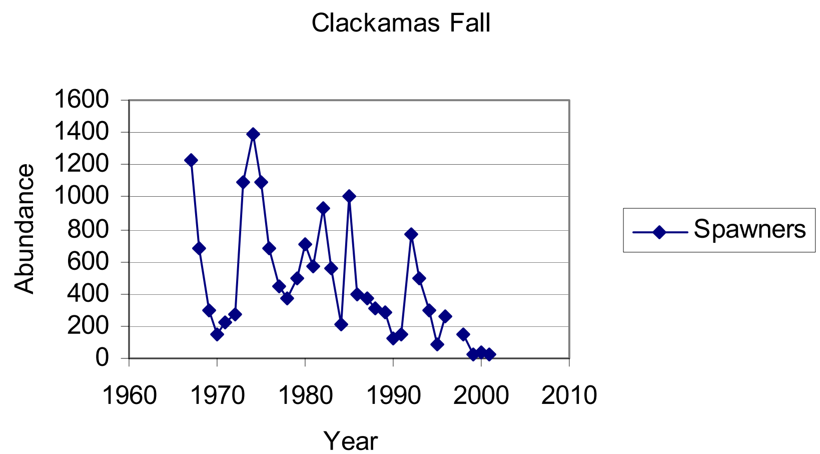


Figure A.2.5.10. Clackamas fall chinook population abundance.

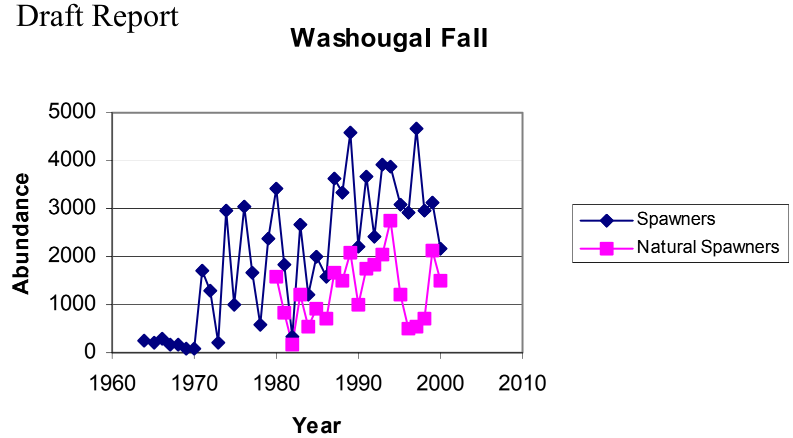


Figure A.2.5.11. Washougal fall chinook population abundance.

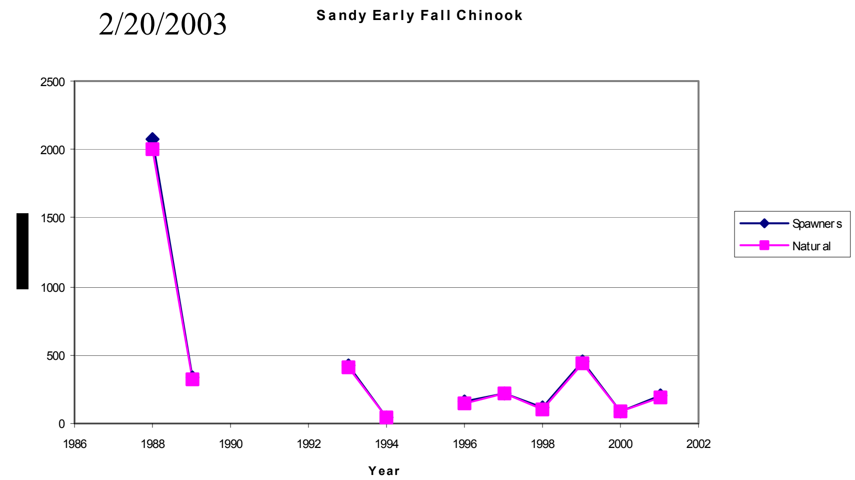


Figure A.2.5.12. Sandy fall chinook population abundance.

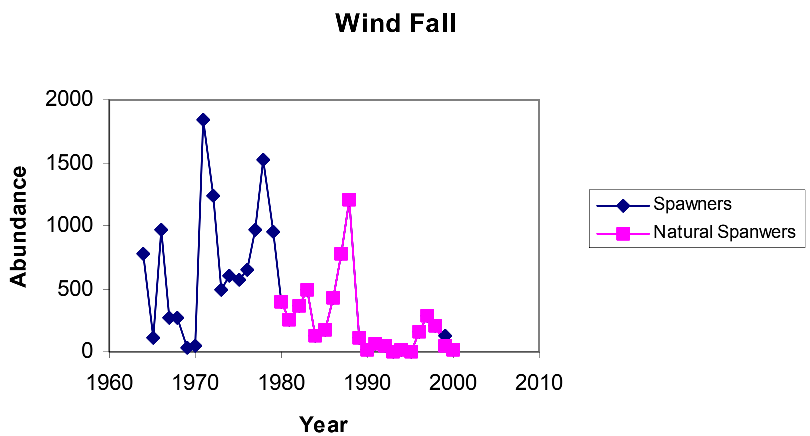


Figure A.2.5.13. Wind fall chinook abundance. The Wind is a component of the Upper Gorge fall Chinook population.

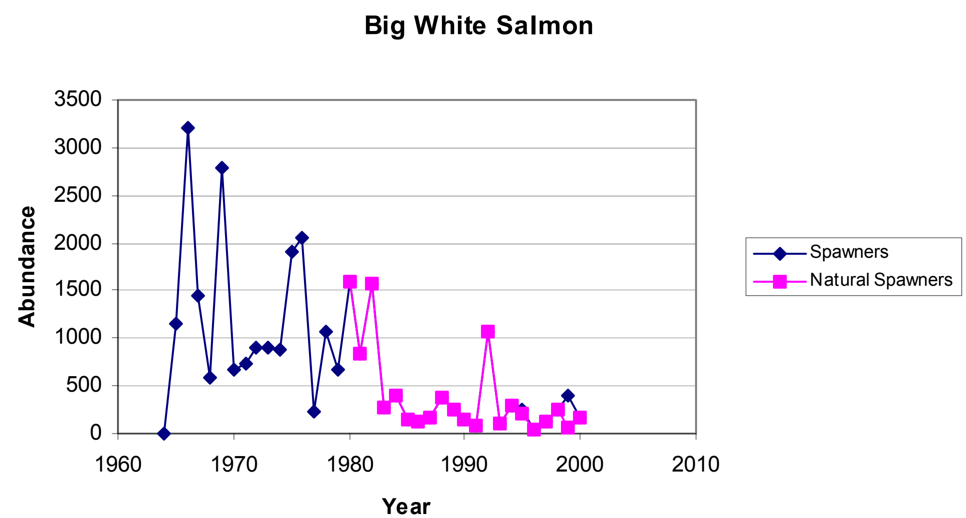


Figure A.2.5.14. Big White Salmon fall chinook population abundance.

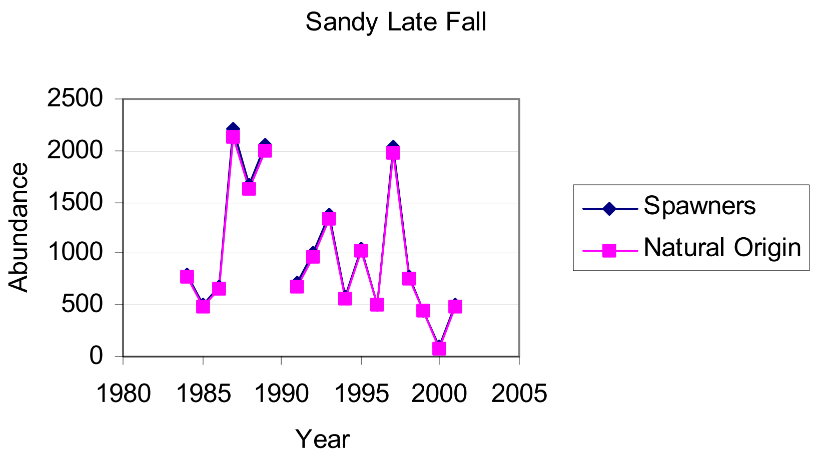


Figure A.2.5.15. Sandy late fall ("bright") chinook population abundance.

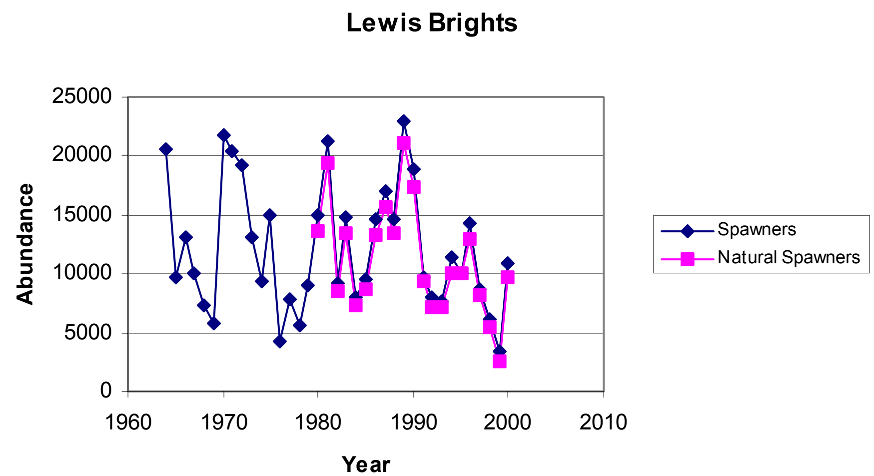


Figure A.2.5.16. Lewis late fall ("bright") chinook population abundance.

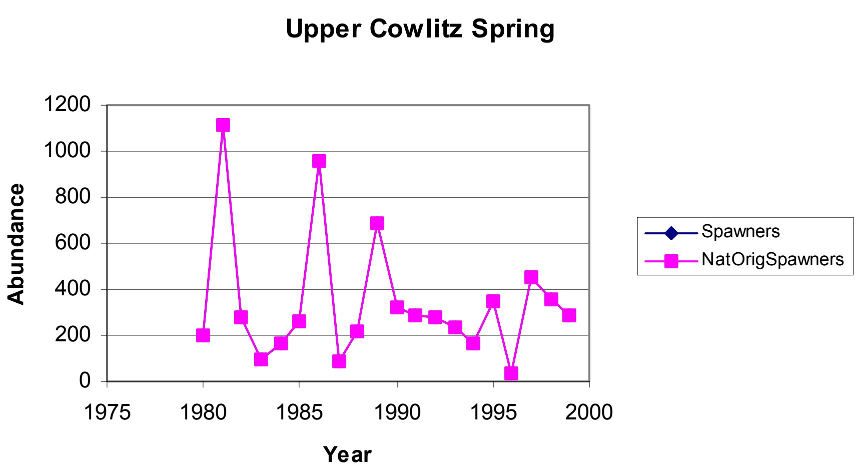


Figure A.2.5.17. Upper Cowlitz spring chinook population abundance.

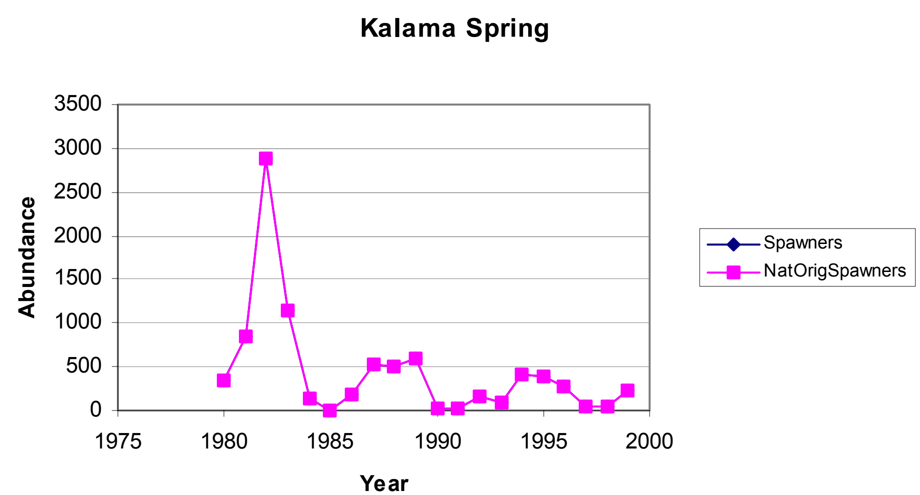


Figure A.2.5.18. Kalama spring chinook population abundance.

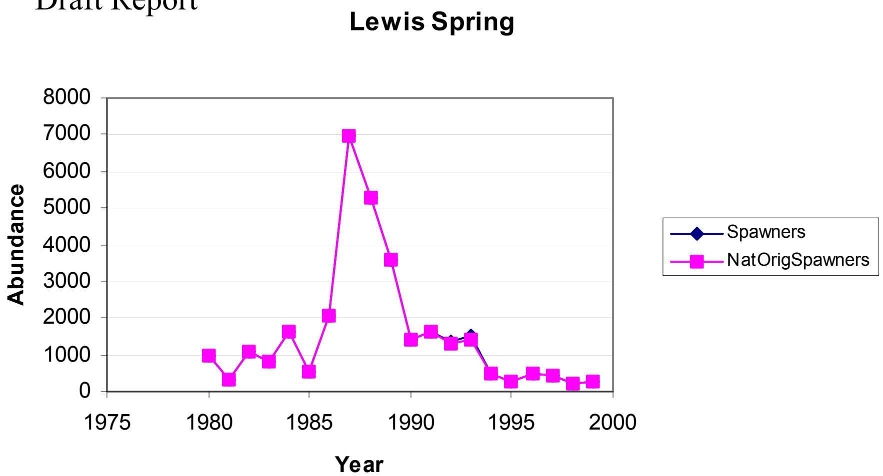


Figure A.2.5.19. Lewis spring chinook population abundance.

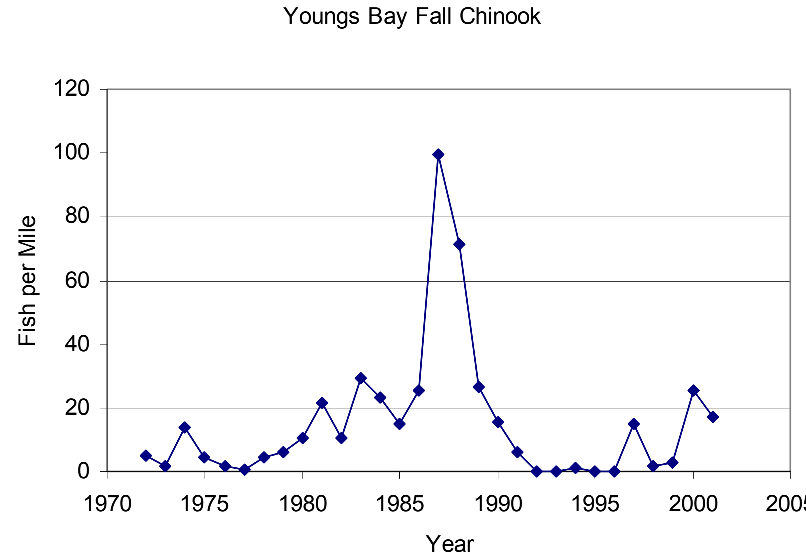


Figure A.2.5.20. Youngs Bay fish per mile.

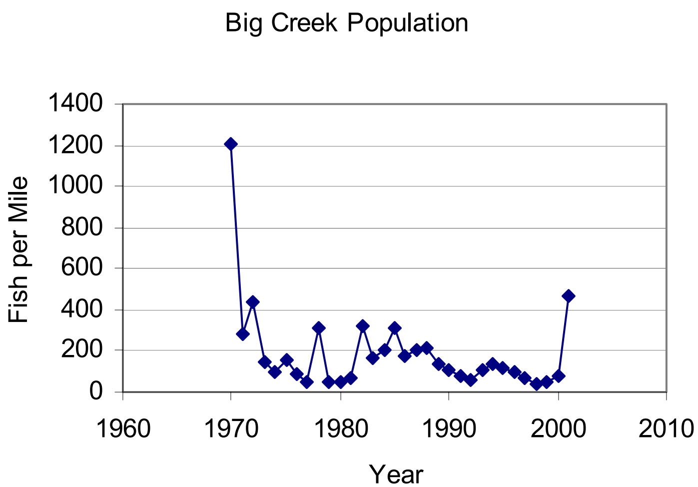


Figure A.2.5.21. Big Creek population fish per mile.

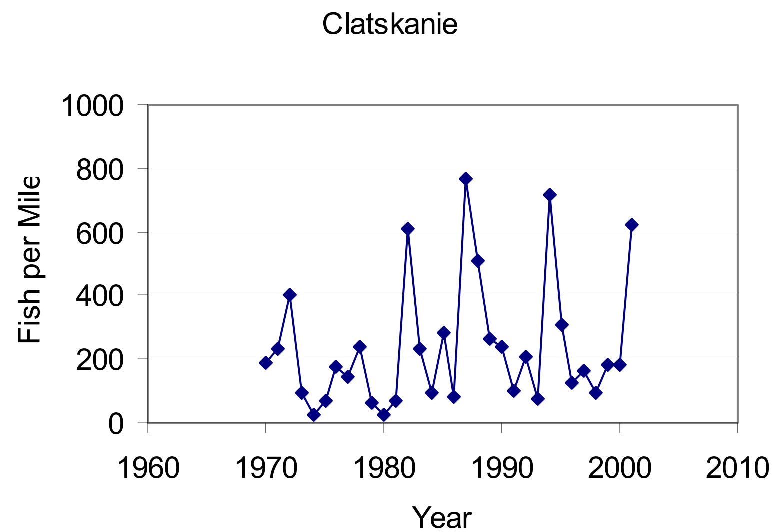


Figure A.2.5.22. Clatskanie population fish per mile.

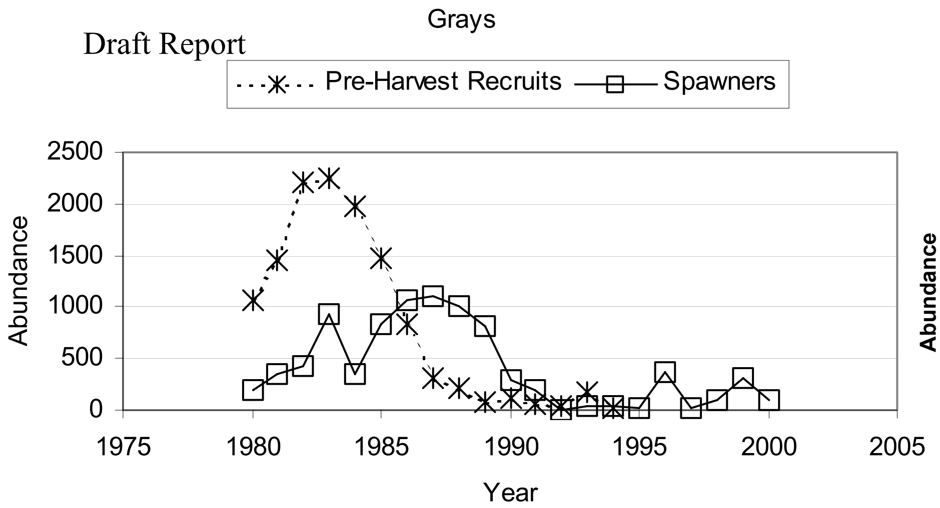


Figure A.2.5.23. Preharvest recruits and spawners for Grays River fall Chinook population.

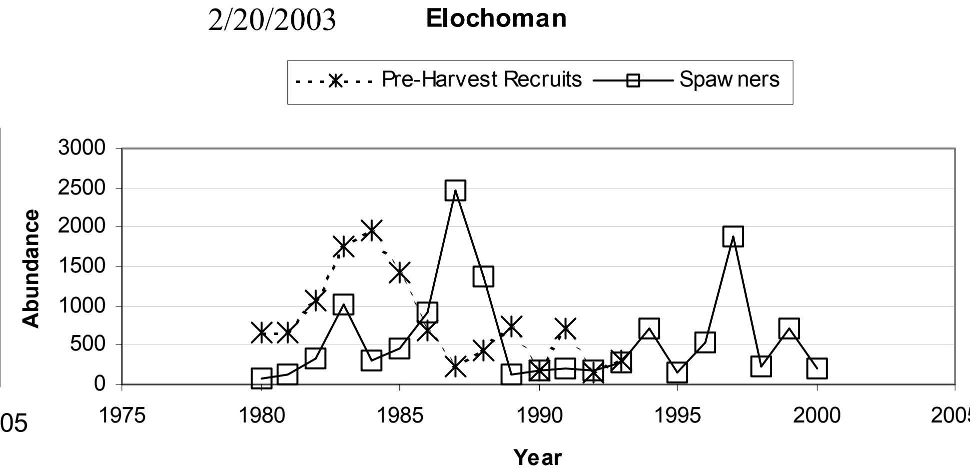


Figure A.2.5.24. Preharvest recruits and spawners for Elochoman fall Chinook population.

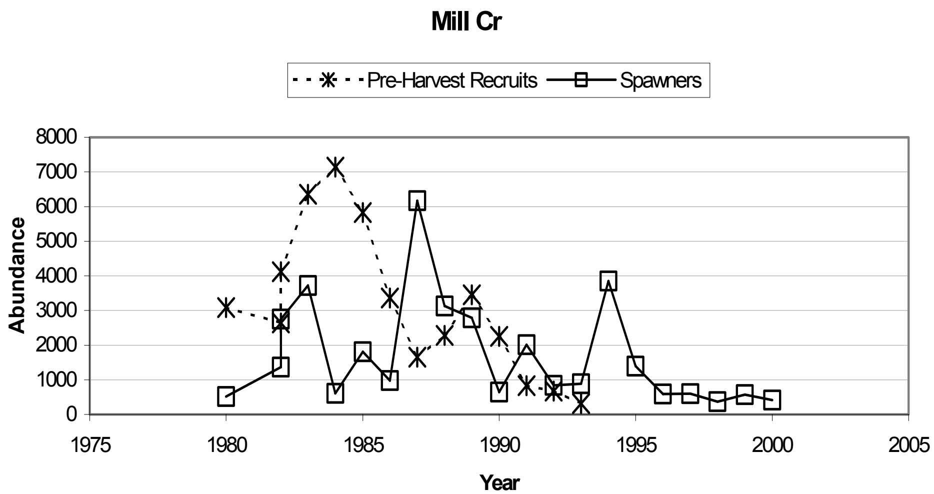


Figure A.2.5.25. Preharvest recruits and spawners for Mill, Germany, Abernathy fall Chinook population.

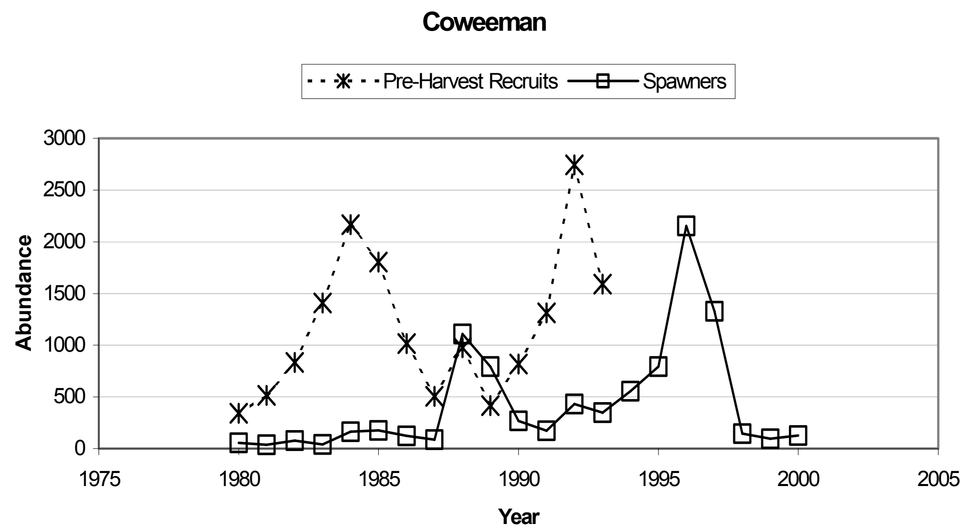


Figure A.2.5.26. Preharvest recruits and spawners for Coweeman fall Chinook population.

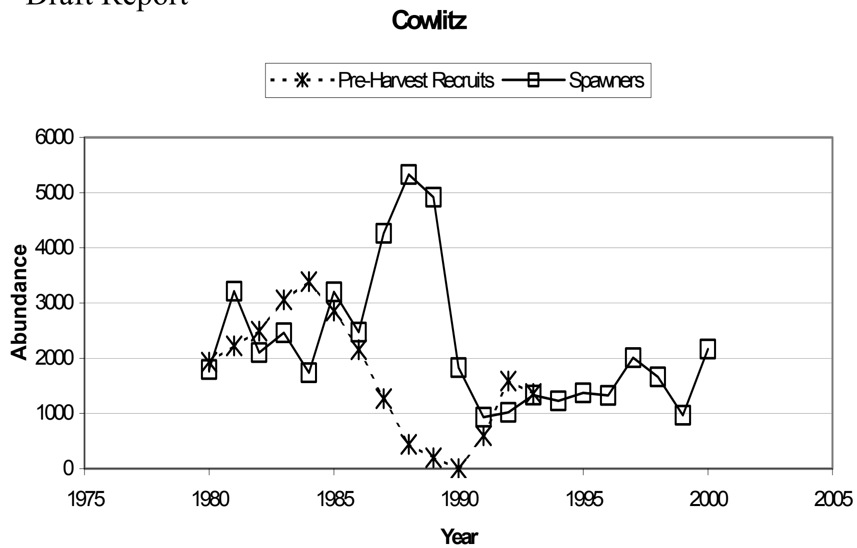


Figure A.2.5.27. Preharvest recruits and spawners for Lower Cowlitz River fall chinook population.

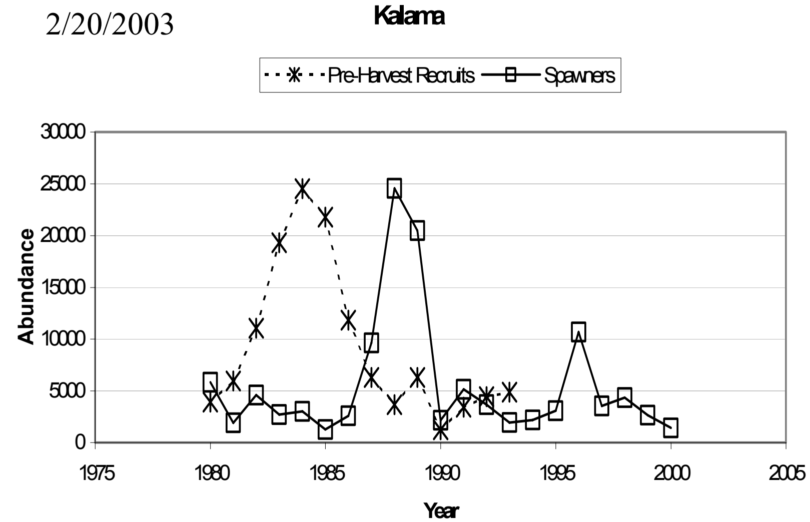


Figure A.2.5.28. Preharvest recruits and spawners for Kalama fall chinook population.

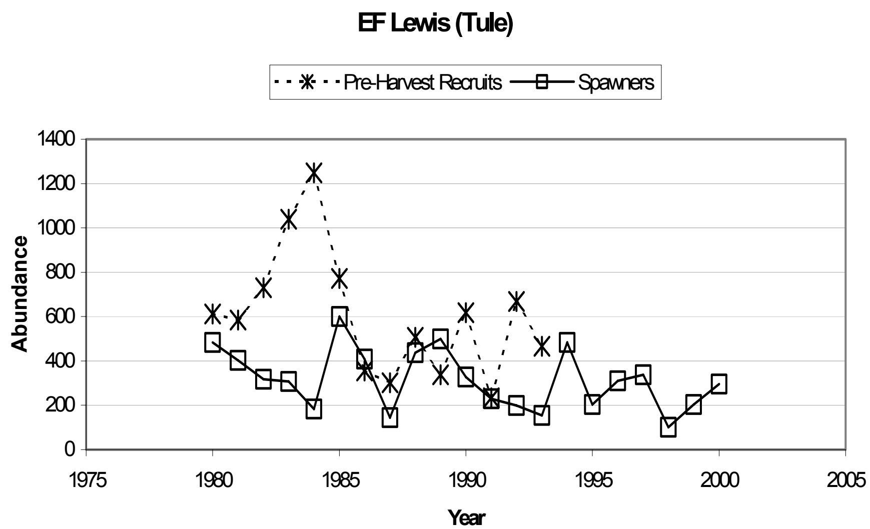


Figure A.2.5.29. Preharvest recruits and spawners for East Fork Lewis River fall population. The East Fork Lewis is a component of the Salmon/Lewis fall chinook population.

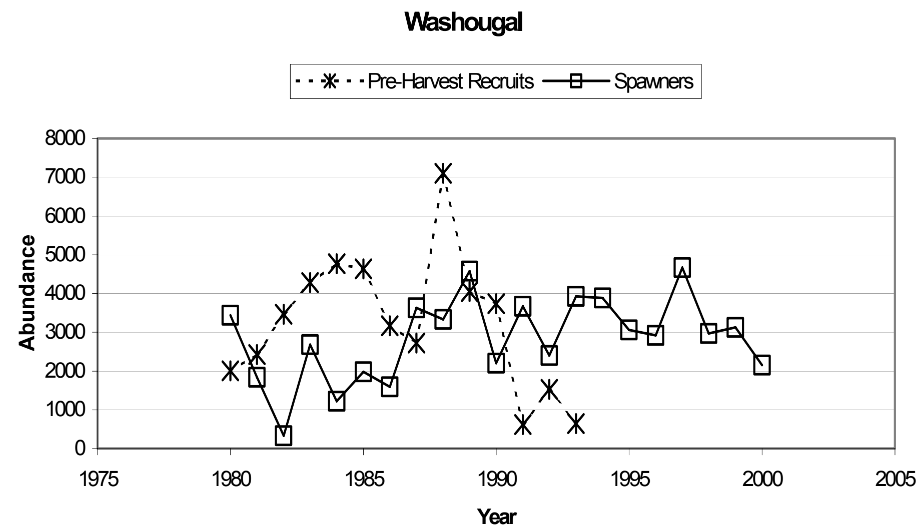


Figure A.2.5.30. Preharvest recruits and spawners for Washougal fall Chinook population.

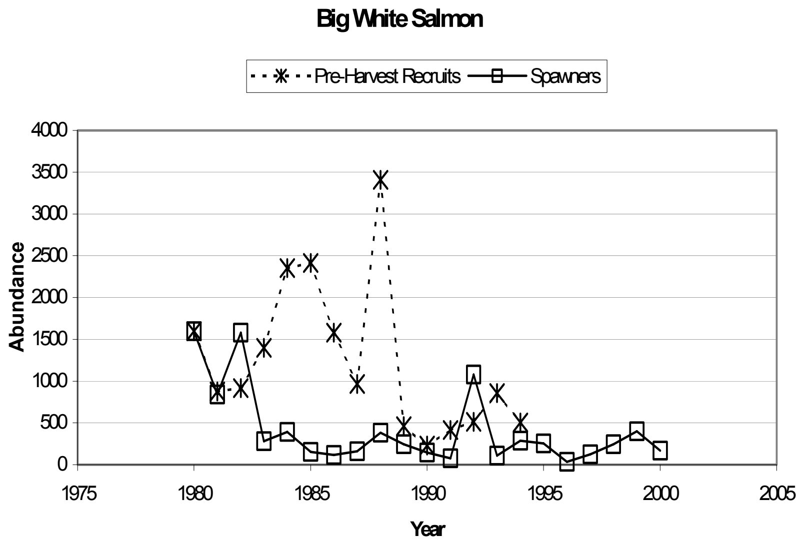


Figure A.2.5.31. Preharvest recruits and spawners for Big White Salmon fall chinook population.

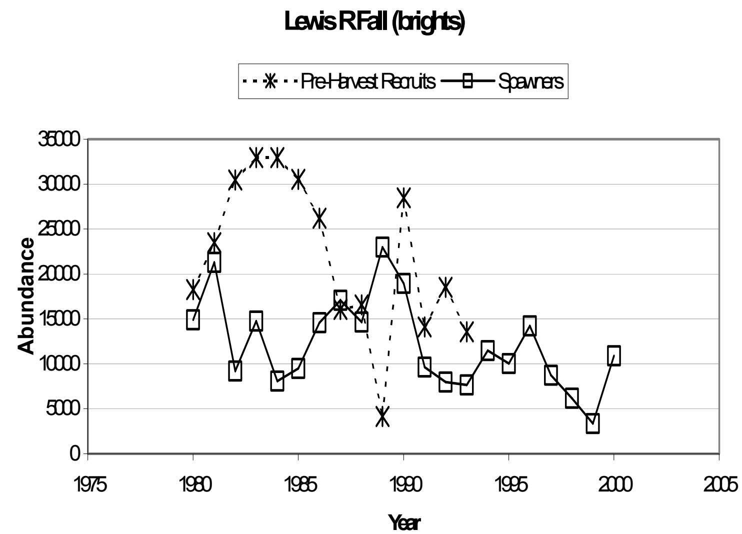


Figure A.2.5.32. Preharvest recruits and spawners for Lewis River late fall ("bright") chinook population.

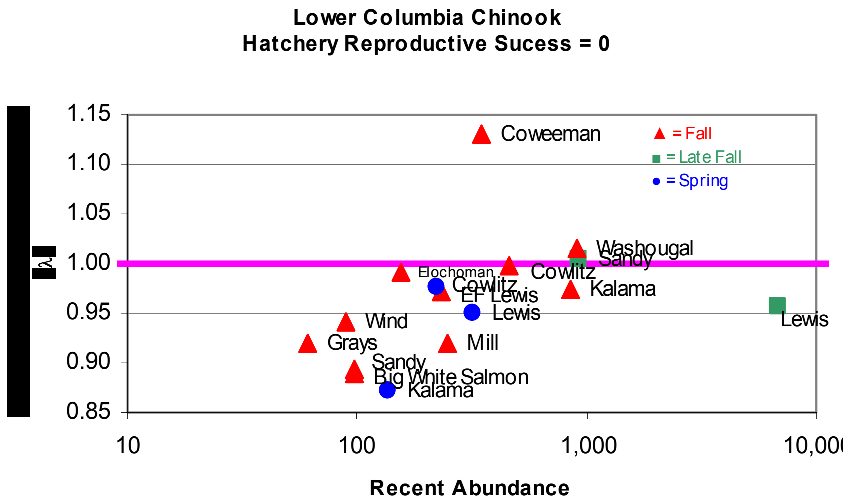


Figure A.2.5.33. Long-term trend vs. recent abundance. NOTE LOG SCALE OF X-AXIS.

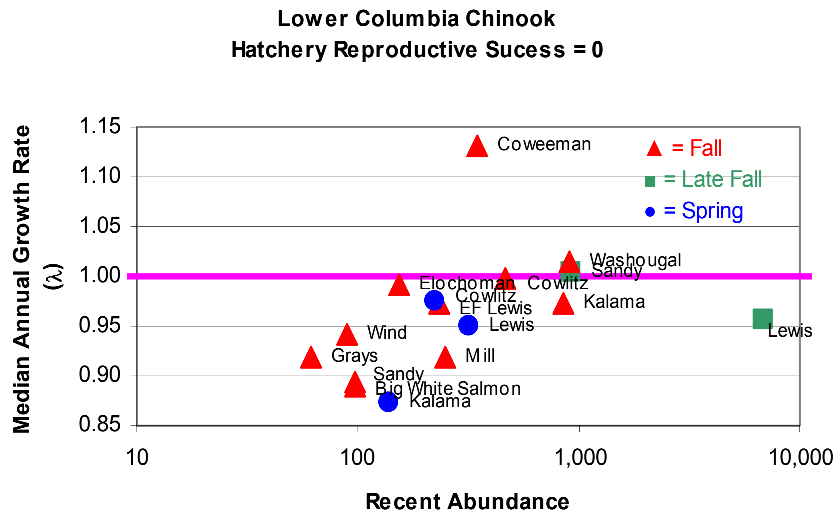


Figure A.2.5.34. Long-term lambda vs. recent abundance. Lambda calculated assuming hatchery fish have a reproductive success of zero. NOTE LOG SCALE OF X-AXIS.

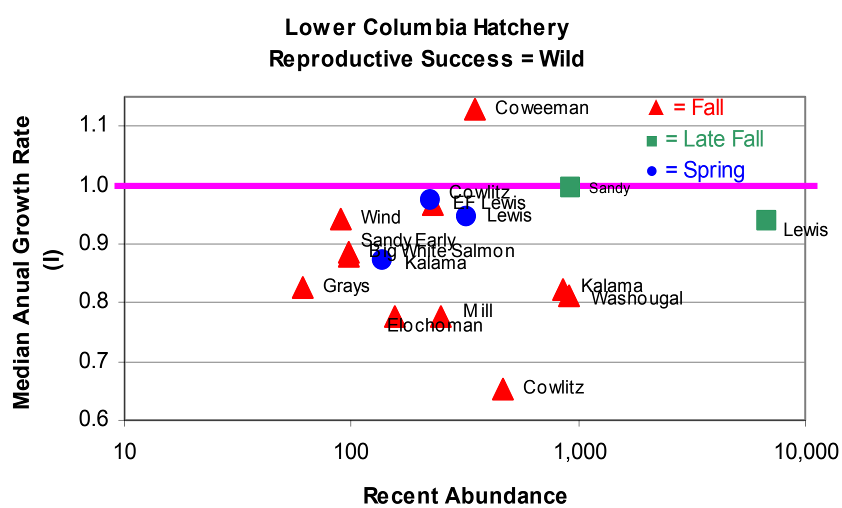


Figure A.2.5.35. Long-term lambda vs. recent abundance. Lambda calculated assuming hatchery fish have a reproductive success equivalent to that of natural origin fish. NOTE LOG SCALE OF X-AXIS.

A.2.6 UPPER WILLAMETTE CHINOOK

A.2.6.1 Previous BRT Conclusions

- A majority of the previous BRT concluded that the Lower Columbia River ESU is likely to become endangered in the foreseeable future. A minority felt that chinook salmon in this ESU were not presently in danger of extinction, nor were they likely to become so in the foreseeable future.
- The BRT was concerned about the few remaining populations of spring chinook salmon in the Upper Willamette River ESU, and the high proportion of hatchery fish in the remaining runs.
- The BRT noted with concern that ODFW was able to identify only one remaining naturally-reproducing population in this ESU–the spring chinook salmon in the McKenzie River.
- Severe declines in short-term abundance had occurred throughout the ESU, and the McKenzie River population continued to decline precipitously, indicating that it may not be self-sustaining.
- The potential for interactions between native spring-run and introduced fall-run chinook salmon had increased relative to historical times due to fall-run chinook salmon hatchery programs and the laddering of Willamette Falls.
- The declines in spring chinook salmon in the Upper Willamette River ESU can be attributed in large part to the extensive habitat blockages caused by dam construction.
- The BRT was encouraged by efforts to reduce harvest pressure on naturally-produced spring chinook salmon in Upper Willamette River tributaries, and the increased focus on selective marking of hatchery fish should help managers targeting specific populations of wild or hatchery chinook salmon.
- Currently listed as threatened.

A.2.6.2 New Data and Analyses

New Data include:

- Spawner abundance through 2002 in Clackamas, 2001 in McKenzie and 2001 at Willamette Falls.
- Updated redd surveys in the basin.
- New estimates of the fraction of hatchery origin spawners in McKenzie and North Santiam from otolith marking study.
- First estimate of hatchery fraction in Clackamas (2002 data).
- Information on recent hatchery releases.

New analyses include:

- Designation of relatively demographically independent populations.
- Recalculation of previous BRT metrics in McKenzie with additional years data.
- Estimates of current and historically available kilometers of stream.
- Update on current hatchery releases.

Historical population structure—As part of its effort to develop viability criteria for UW chinook, The Willamette/Lower Columbia Technical Recovery Team (WLC-TRT) has identified historically demographically independent populations (Myers et al. 2002). Population boundaries are based on an application of Viable Salmonid Populations definition (McElhany et al. 2000). Myers et al. hypothesized that the ESU historically consisted of 7 spring run populations (Figure A.2.6.1). The populations identified in Myers et al. (2002) are used as the units for the new analyses in this report.

Abundance and trends

References for abundance time series and related data are in Appendix A.5.3. Recent abundance of natural-origin spawners, recent fraction of hatchery-origin spawners, and recent harvest rates for UW Chinook populations are summarized in Table A.2.6.1. The total number of spring chinook spawners passing Willamette Falls from 1953 to 2001 is shown in Figure A.2.6.2. All spring chinook in the ESU, except those entering the Clackamas River, must pass Willamette Falls. There is no assessment of the ratio of hatchery-origin to wild-origin chinook passing the falls, but the majority of fish are undoubtedly of hatchery origin. (Natural-origin fish are defined has having had parents that spawned in the wild as opposed to hatchery -origin fish whose parents spawned in a hatchery.) Individual population's status is discussed below.

Clackamas—The count of spring chinook passing the North Fork dam on the Clackamas from 1958 to 2002 are shown in Figure A.2.6.3 (Cramer 2002). The total number of chinook passing above the dam has exceeded 1,000 in most years since 1980 and the last several year show large increases. However, the majority of these fish are likely of hatchery origin. The only year for which hatchery origin estimates are available is 2002 and the estimate is 64% of hatchery origin. Although the majority of spring chinook spawning habitat is above North Fork Dam, spawning is observed below the dam. The majority of spawning below the dam is also considered to be by hatchery origin spawners. The population has shown substantial increases in total abundance (mixed hatchery and natural origin) in the last couple of years.

Molalla—A 2002 survey of 16.3 miles of stream in the Molalla found 52 redds. However, 93% of the carcasses recovered in the Molalla in 2002 were fin-clipped and of hatchery origin (Schroeder et al 2002). Fin-clip recovery fractions for spring chinook in the Willamette tend to underestimate the proportion of hatchery origin spawners, so the true fraction is likely in excess of 93 % (i.e. near 100%). The Molalla natural spring chinook population is believed to be extirpated, or nearly so.

North Santiam—Survey estimates of redds per mile in the North Santiam are shown in Figure A.2.6.4 (from Schroeder et al 2002). The number of stream miles surveyed varies between 26.8 and 43.5. The total redds counted in a year varies between 116 and 310. Schroeder et al. (2002) estimate an escapement of 94 natural origin spawners above Bennett Dam in 2000 and 151 in 2001. These natural-origin spawners were greatly outnumbered by hatchery origin spawners (2,192 and 6,635 in 2000 and 2001 respectively). This resulted in estimated 94% hatchery origin spawners in 2000 and 98% in 2001. This population is not considered self-sustaining.

South Santiam—A 2002 survey of 50.8 miles of stream in the South Santiam found 982 redds. However, 84% of the carcasses recovered in the Molalla in 2002 were fin-clipped and of hatchery origin (Schroeder et al 2002). Fin-clip recovery fractions for spring chinook in the Willamette tend to underestimate the proportion of hatchery origin spawners, so the true fraction is likely in excess of 84 %. This population is not considered self-sustaining.

Calapooia—A 2002 survey of 11.1 miles of stream in the Calapooia above Brownsville found 16 redds (Schroeder et al 2002). The carcasses recovered in the Calapooia in 2002 were too decomposed to determine the presence or absence of fin clips. However, it was assumed that all the fish were surplus hatchery fish outplanted from the South Santiam hatchery. (Schroeder et al. 2002). The Calapooia natural spring chinook population is believed to be extirpated, or nearly so.

McKenzie—The time series of total spring chinook counts and natural origin fish passing Leaburg dam on the McKenzie is shown in Figure A.2.6.5. The average fraction of hatchery-origin fish passed above the dam from 1998 to 2001 was estimated at 26%. Redds are observed below Leaburg Dam, but the fraction of hatchery-origin fish is higher (Schroeder et al 2002). The fraction of fin-clipped spring chinook carcasses recovered below Leaburg was 72% in 2000 and 67% in 2001. Again, fin clip recoveries tend to underestimate the fraction of hatchery-origin spawners. The spring chinook population above Leaburg Dam in the McKenzie is considered the best in the ESU, but with over 20% of the fish of hatchery origin, it is difficult to determine if this population would be naturally self sustaining. The population has shown substantial increases in total abundance (mixed hatchery and natural origin) in the last couple of years.

Middle Fork Willamette—A 2002 survey of 17 miles of the mainstem Middle Fork found 64 redds. However, 77% of the carcasses recovered in the Middle Fork in 2002 were fin-clipped and of hatchery origin (Schroeder et al 2002). In Fall Creek, a tributary of the Middle Fork, 171 redds in 13.3 miles were found in 2002. The 2002 carcass survey found 39% of fish fin-clipped. Fin-clip recovery fractions for spring chinook in the Willamette tend to underestimate the proportion of hatchery origin spawners. This population is not considered self-sustaining.

No formal trend analyses were conducted on any of the UW chinook populations. The two populations with long time series of abundance (Clackamas and McKenzie) have insufficient information on the fraction of hatchery-origin spawners to permit a meaningful analysis.

Loss of habitat from barriers—An analysis was conducted by Steel and Sheer (2002) to assess the number of stream km historically and currently available to salmon populations in the UW (Table A.2.6.1). Stream km usable by salmon are determined based on simple gradient cut offs and on the presence of impassable barriers. This approach will over estimate the number of usable stream km, as it does not take into consideration habitat quality (other than gradient). However, the analysis does indicate that for some populations the number of stream habitat km currently accessible is significantly reduced from the historical condition.

Hatchery releases

A large number of spring chinook are released in the Upper Willamette as mitigation for the loss of habitat above federal hydroprojects (Table A.2.6.2). This hatchery production is considered a potential risk, because it masks the productivity of natural population, interbreed of hatchery and natural fish poses potential genetic risks and the incidental take from the fishery promoted by the hatchery production can increase adult mortality. Harvest retention is only allowed for hatchery marked fish, but take from hooking mortality and non-compliance is still a potential issue.

Fall chinook are not native to the upper Willamette and are not part of the Upper Willamette chinook ESU. Fall chinook hatchery fish are no longer released into the upper Willamette, though there have been substantial releases in the past (Figure A.2.6.6).

A.2.6.3 New ESU Information

Based on the updated information provided in this report, the information contained in previous LCR status reviews, and preliminary analysis by the WLC-TRT, we have tentatively identified the number of historical and currently viable populations (Table A.2.6.3). This summary indicates that the ESU is substantially modified from historical population structure. Most populations would are considered extirpated or nearly so. The only population considered potentially self-sustaining is the McKenzie. However, its abundance has been relatively low (low thousands) with a substantial number of these fish being of hatchery origin. The population has shown a substantial increase in the last couple of years, hypothesized to be a result of increase ocean survival. It is unknown what ocean survivals will be in the future and the long-term sustainability of this population in uncertain.

Table A.2.6.1. Historical populations of Upper Willamette spring chinook. The recent abundance is the geometric mean of natural origin spawners of the last five years of available data and the min-max are the lowest and highest five-year geometric means in the time series. Natural origin fish had parents that spawned in the wild as opposed to hatchery origin fish whose parents were spawned in a hatchery. The data years are the data years used for the abundance min-max estimates, the extinction risk estimate and the trends (see Figures). Longer time series may be available for spawners only (see figures) but hatchery fraction information was required to estimate means, extinction risk and trends. For McKenzie population, the fraction hatchery is the average percent of spawners of hatchery origin over the last four years. For Clackamas only one hatchery fraction estimate is available (2002). Hatchery fraction in the Molalla, South Santiam and Middle Fork and minimum estimates based on the ratio of adipose marked verses unmarked fish recovered in 2001 (Schroeder et al 2002).

Population	**Recent Abundance**	**Data Years**	**Hatchery Fraction (%)**	**Potential Current Habitat (%)**	**Potential Historical Habitat (km)**	**Current to Historical Habitat Ratio**
Clackamas River	830	1958-2002	64	369	475	78
Molalla River	Extirpated (or nearly so)		>93	432	688	63
North Santiam River	119 (above Bennett Dam)	2000-2001	97	173	269	64
South Santiam River			>84	445	658	68
Calapooia River	Extirpated (or nearly so)			163	253	65
McKenzie	1664 (824-1664)	1970-2001	26	283	382	74
Middle Fork Willamette River			>77	197	425	46
Total	1,787			2,063	3,150	65
Average			26			

Table A.2.6.2. Upper Willamette spring chinook hatchery releases (compiled by Waknitz 2002).

Watershed	Years	Hatchery	Stock	Release Site	Total
Willamette R	1994	Dexter Pd	Mckenzie	L Willamette R	73,028
	1995	Dexter Pd	Willamette	L Willamette R	137,573
	1995	Lone Star	Clackamas	L Willamette R	59,654
	1995	Marion Forks	N Santiam	L Willamette R	40,320
	1993, 1994	Mckenzie	Mckenzie	L Willamette R	344,089
	1992, 1993	Step	Clackamas	L Willamette R	70,193
	1993, 1994	Step	Mckenzie	L Willamette R	331,446
	1993-1995	Mckenzie	Clackamas	L Willamette R	125,585
	1996-1999	Willamette	Mckenzie	L Willamette R	225,122
	1995-1996	Willamette	N Santiam	L Willamette R	81,513
	1995-1999	Mckenzie	Mckenzie	L Willamette R	574,117
Clackamas R	1991-1994	Clackamas	Clackamas	Clackamas R	4,358,092
	1995-2002	Clackamas	Clackamas	Clackamas R	9,182,916
	1996-2001	Mckenzie	Mckenzie	Clackamas R	1,332,542
	1991	Eagle Creek Nfh	Clackamas	Eagle Cr	556,814

Table A.2.6.3. Number of populations in the ESU. Populations with “some current natural production” have some natural origin recruits present but are not necessarily considered self-sustaining (“viable”).

	Total
Historical	7
Some current natural production	5-6
Currently “viable”	0-1

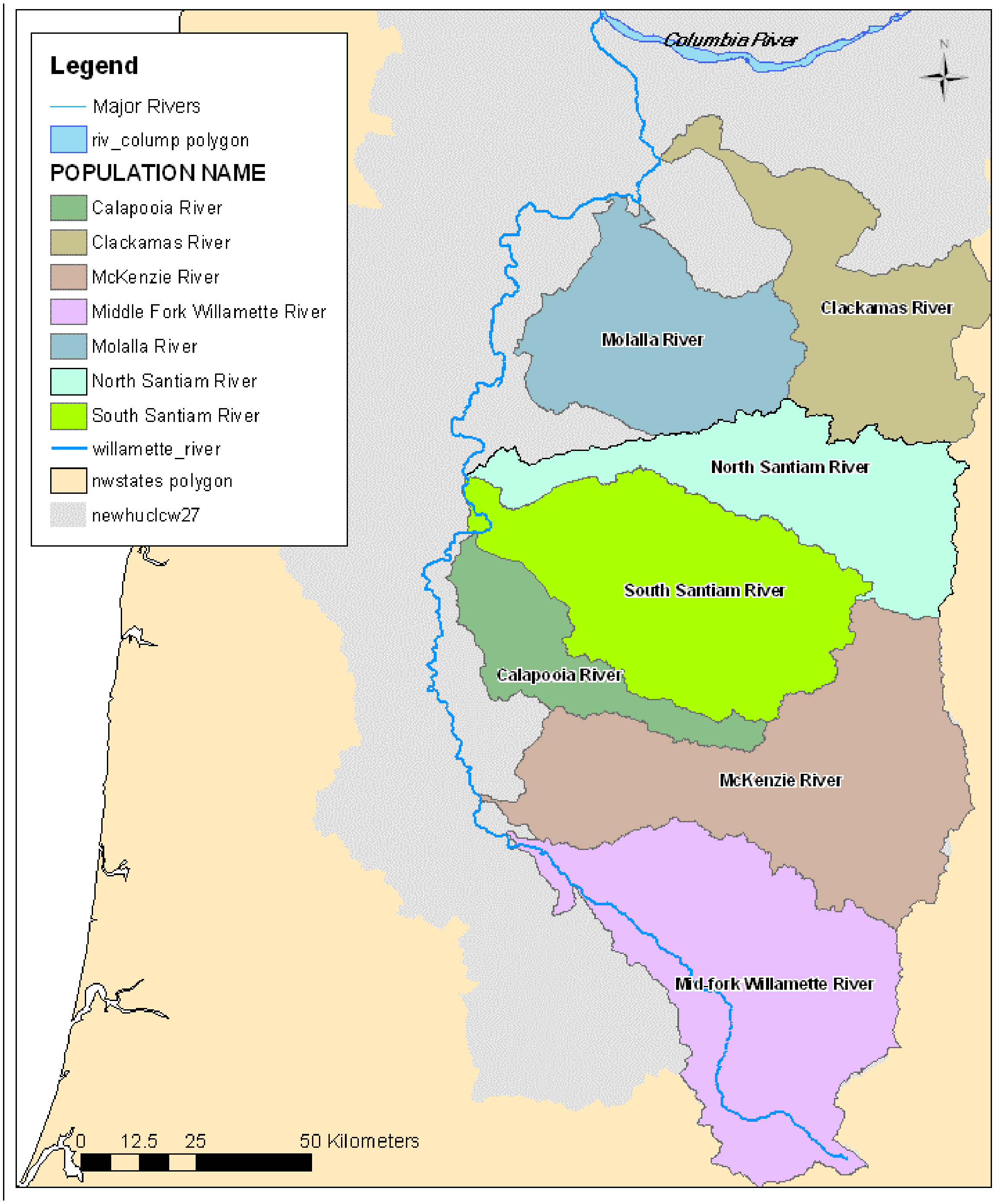


Figure A.2.6.1. Historical populations of spring chinook in the Willamette ESU (Myers et al. 2002).

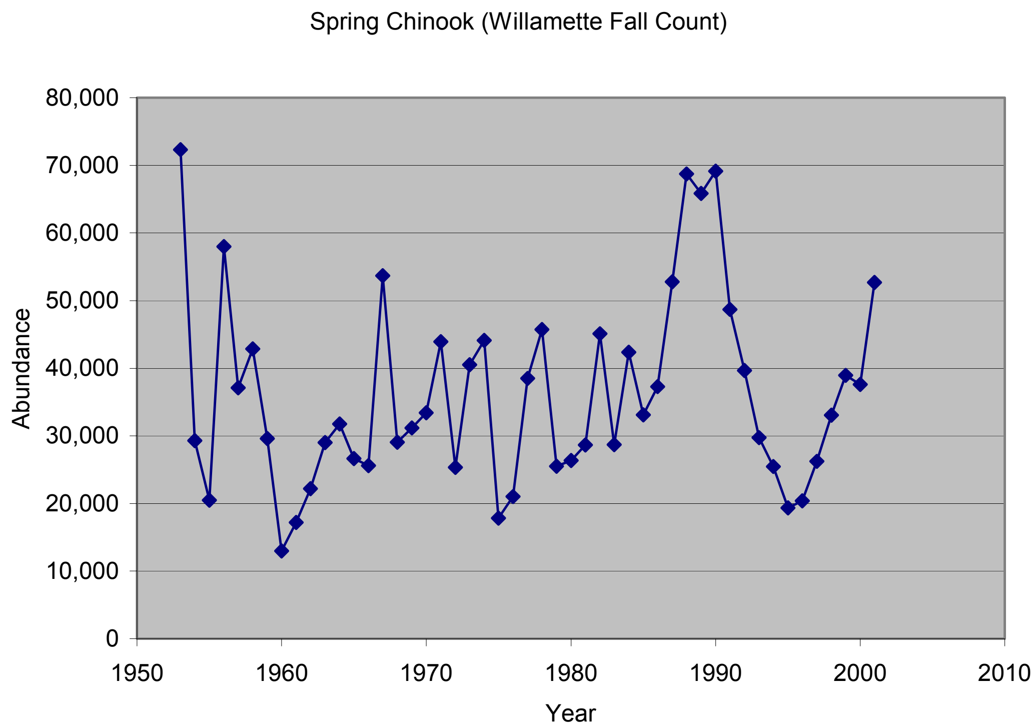


Figure A.2.6.2. Counts of spring chinook passing Willamette Falls.

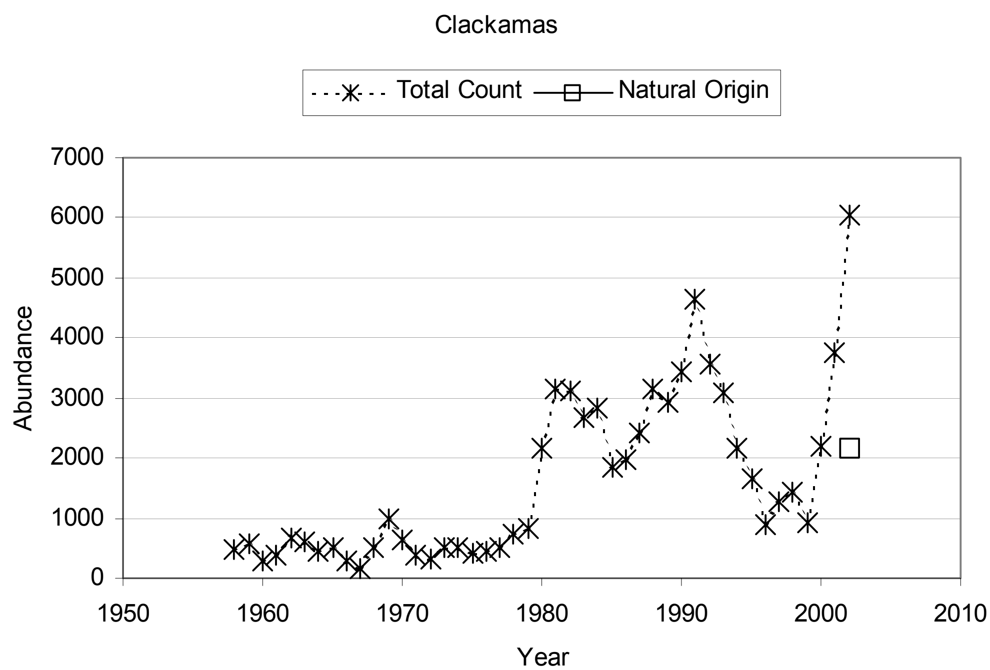


Figure A.2.6.3. Counts of Spring Chinook passing North Fork Dam on the Clackamas River (Cramer 2002). The total count is all fish passing above the dam. There is only one estimate (in 2002) of the number of fish passing above the dam that are of natural origin.

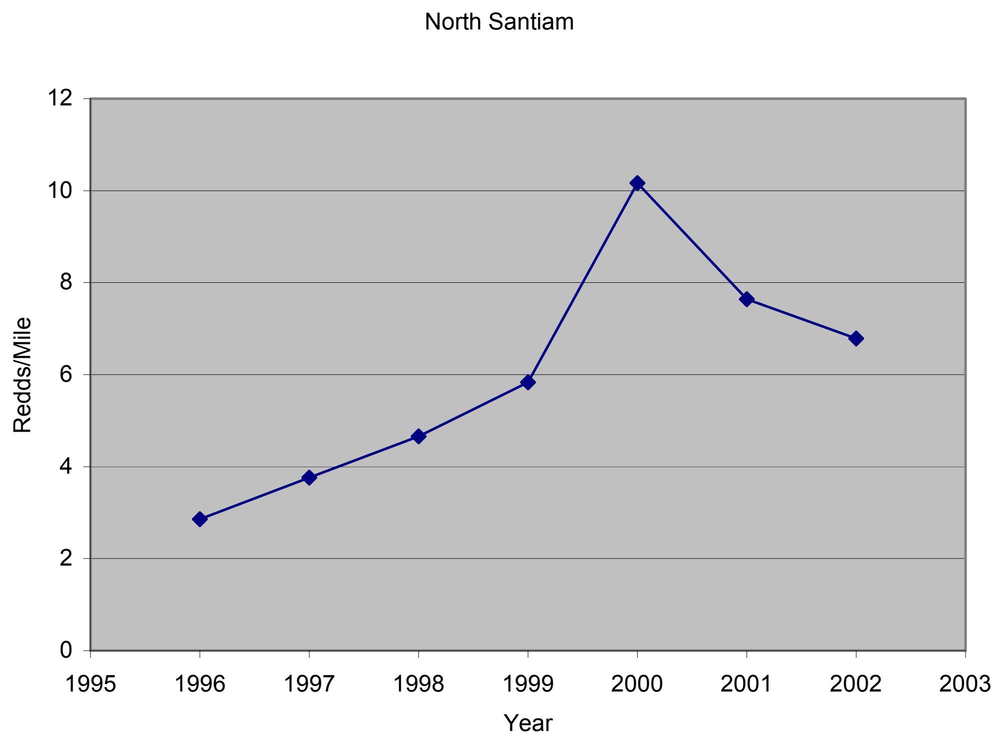


Figure A.2.6.4. North Santiam redds per mile (data from Schroeder et al. 2002). The number of stream miles surveyed varies between 26.8 and 43.5 miles. The total redds count in a year varies between 116 and 310. Over 95% of the spawners are estimated of hatchery origin

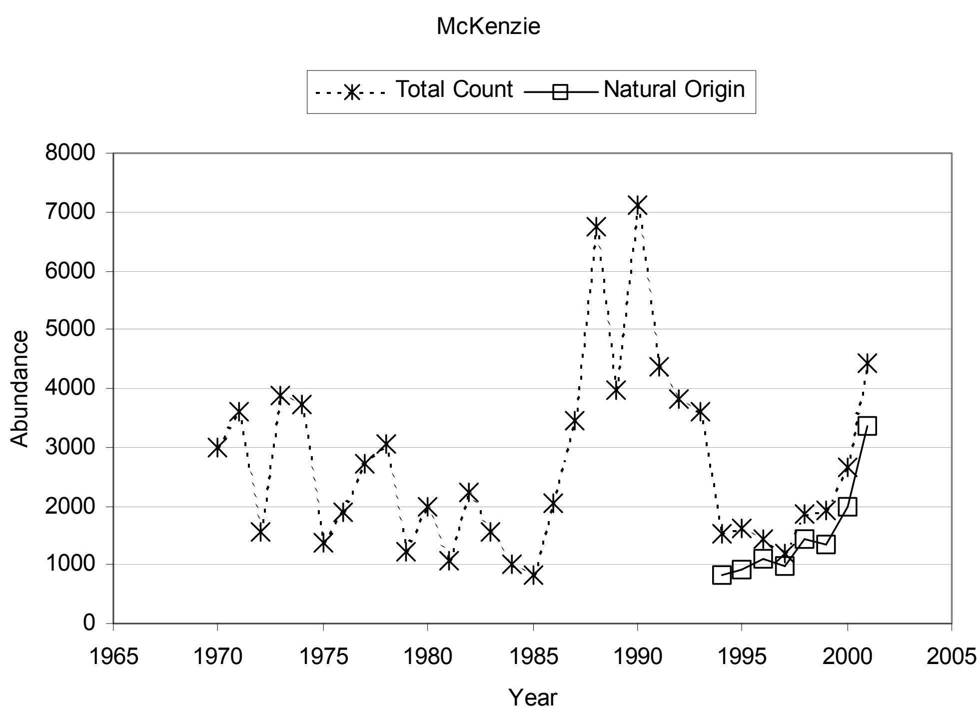


Figure A.2.6.5. Counts of spring chinook at Leaburg Dam.

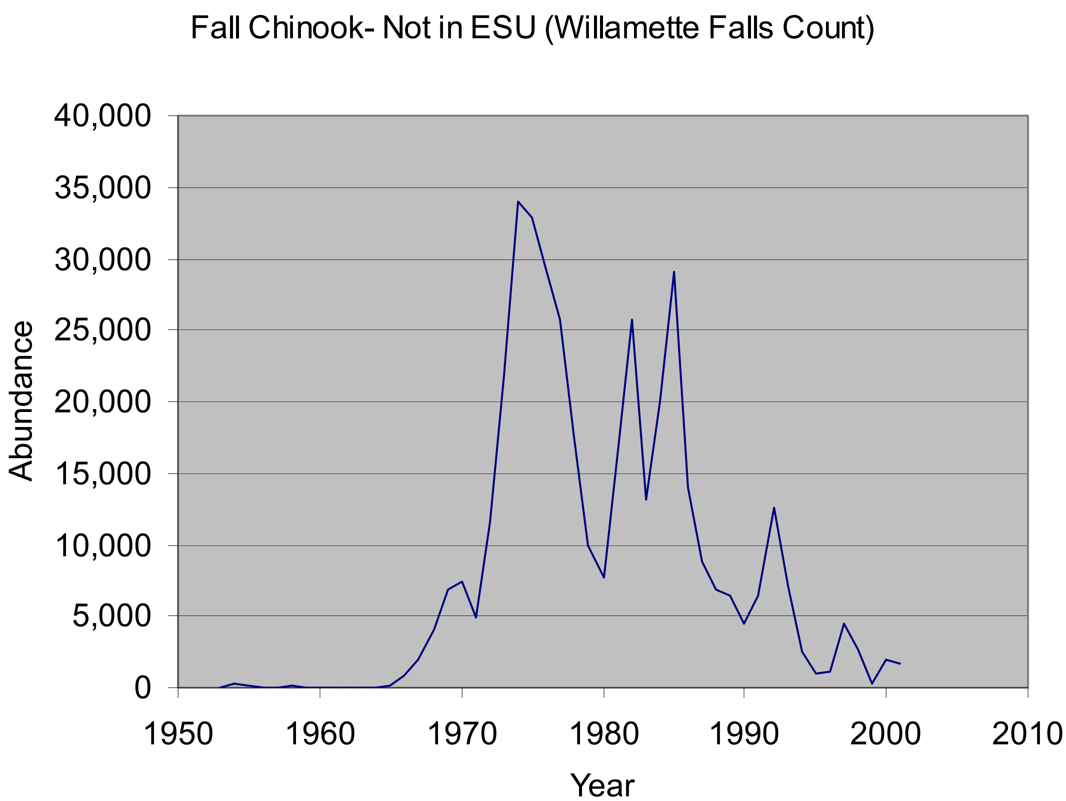


Figure A.2.6.6. Counts of fall chinook at Willamette Falls. Fall chinook are not native in the Upper Willamette and are not in the in the Upper Willamette Chinook ESU.

A.2.7 CALIFORNIA COASTAL CHINOOK

A.2.7.1 Previous BRT Conclusions

The status of chinook salmon throughout California and the Pacific Northwest was formally assessed in 1998 (Myers, et al. 1998). Substantial scientific disagreement about the biological data and its interpretation persisted for some Evolutionarily Significant Units (ESUs); these ESUs were reconsidered in a subsequent status review update (NMFS 1999). Information from those reviews regarding ESU structure, analysis of extinction risk, risk factors, and hatchery influences is summarized in the following sections.

ESU structure

The initial status review proposed a single ESU of chinook salmon inhabiting coastal basins south of Cape Blanco and the tributaries to the Klamath River downstream of its confluence with the Trinity River (Myers et al 1998). Subsequent review of an augmented genetic data set and further consideration of ecological and environmental information led to the division of the originally proposed ESU into the Southern Oregon and Northern California Coastal Chinook Salmon ESU and the California Coastal Chinook Salmon ESU (NMFS 1999). The California Coastal Chinook Salmon ESU currently includes chinook salmon from Redwood Creek to the Russian River (inclusive).

Summary of risk factors and status

The California Coastal Chinook Salmon ESU is listed as Threatened. Primary causes for concern were low abundance, reduced distribution (particularly in the southern portion of the ESU's range), and generally negative trends in abundance; all of these concerns were especially strong for spring-run chinook salmon in this ESU (Myers et al. 1998). Data for this ESU are sparse and, in general of limited quality, which contributes to substantial uncertainty in estimates of abundance and distribution. Degradation of the genetic integrity of the ESU was considered to be of minor concern and to present less risk for this ESU than for other ESUs.

Previous reviews of conservation status for chinook salmon in this area exist. Nehlsen et al. (1991) identified three putative populations (Humboldt Bay Tributaries, Mattole River, and Russian River) as being at high risk of extinction and three other populations (Redwood Creek, Mad River, and Lower Eel River) as being at moderate risk of extinction. Higgins et al. (1992) identified seven "stocks of concern," of which two populations (tributaries to Humboldt Bay and the Mattole River) were considered to be at high risk of extinction. Some reviewers indicate that chinook salmon native to the Russian River have been extirpated.

Historical estimates of escapement are presented in Table A.2.7.1. These estimates are based on professional opinion and evaluation of habitat conditions, and thus do not represent rigorous estimates based on field sampling. Historical time series of counts of upstream migrating adults are available for Benbow Dam (South Fork Eel River; 1938-1975), Sweasy Dam (Mad River; 1938-1964), and Cape Horn Dam (Van Arsdale Fish Station, Eel River); the

Table A.2.7.1. Historical estimates of abundance of chinook salmon in the California Coastal Chinook Salmon ESU.

Selected Watersheds	***CDFG 1965***	**Wahle & Pearson 1987**
Redwood Creek	5,000	1,000
Mad River	5,000	1,000
Eel River	55,000	17,000
Mainstem Eel[1]	13,000	
Van Duzen River[1]	2,500	
Middle Fork Eel[1]	13,000	
South Fork Eel[1]	27,000	
Bear River		100
Small Humboldt County Rivers	1,500	
Miscellaneous Rivers North of Mattole		600
Mattole River	5,000	1,000
Noyo River	50	
Russian River	500	50
Total	72,550	20,750

[1]Entries for subbasins of the Eel River Basin are not included separately in the total.

latter represent a small, unknown and presumably variable fraction of the total run to the Eel River. Data from cursory, nonsystematic stream surveys of two tributaries to the Eel River (Tomki and Sprowl Creeks) and one tributary to the Mad River (Canon Creek) were also available; these data provide crude indices of abundance.

Previous status reviews considered the following to pose significant risks to the California Coastal Chinook Salmon ESU: degradation of freshwater habitats due to a variety of agricultural and forestry practices, water diversions, urbanization, mining, and severe recent flood events (exacerbated by land use practices). Special concern was noted regarding the more precipitous declines in distribution and abundance in spring-run chinook salmon. Many of these factors are particularly acute in the southern portion of the ESU range and were compounded by uncertainty stemming from the general lack of population monitoring in California (Myers et al. 1998).

In previous status reviews, the effects of hatcheries and transplants on the genetic integrity of the ESU elicited less concern than other risk factors for this ESU, and were less of a concern for this ESU in comparison to other ESUs.

Listing status

The California Coastal Chinook Salmon ESU is currently listed as “Threatened.”

A.2.7.2 New Data and Analysis

The Technical Recovery Team for the North-Central California Coast Recovery Domain has proposed a set of plausible hypotheses, based largely on geography, regarding the population structure of the California Coast Chinook Salmon ESU (Table A.2.7.2), but has concluded that insufficient information exists to discriminate among these hypotheses (NCCC-TRT, *in preparation*). Data are not available for all of the potential populations; only those for which data are available are considered below.

New or updated time series for chinook salmon in this ESU include (1) counts of adults reaching Van Arsdale Fish Station near the effective headwater terminus of the Eel River; (2) cursory, quasi-systematic spawner surveys on Canon Creek (tributary to the Mad River), Tomki Creek (tributary to the Eel River), and Sprowl Creek (tributary to the Eel River); (3) counts of returning spawners at a weir on Freshwater Creek (tributary to

Table A.2.7.2. Plausible hypotheses for independent populations considered by the North Central California Coast Technical Recovery Team. This information is summarized from a working draft report, and should be considered as preliminary and subject to revision.

"Lumped"	"Split"
Redwood Creek	
Mad River	
Humboldt Bay Tributaries	
Eel River[1]	
	South Fork Eel River
	Van Duzen River
	Middle Fork Eel River
	North Fork Eel River
	Upper Eel River
Bear River	
Mattole River	
Tenmile to Gualala[2]	
Russian River	

[1]Plausible hypotheses regarding the population structure of chinook salmon in the Eel River basin include scenarios ranging from five independent populations (South Fork Eel River, Van Duzen River, Upper Eel River, Middle Fork Eel River, and North Fork Eel River) to a single, strongly structured independent population.

[2]This stretch of the coast comprises numerous smaller basins that drain directly into the Pacific Ocean, some of which appear sufficiently large to support independent populations of chinook salmon. The following hypotheses span much of the range of plausible scenarios: (1) independent populations exist in all basins that exceed a minimum size; (2) independent populations exist only in basins between the Tenmile River and Big River, inclusive, that exceed a minimum size; (3) chinook salmon inhabiting basins along this stretch of coastline exhibit patchy population or metapopulation dynamics in which the occupancy of any given basin is dependent on migrants from other basins, and possibly from larger basins to the north and south; and (4) chinook salmon inhabiting basins between the Tenmile River and Big River, inclusive, exhibit patchy population or metapopulation dynamics in which the occupancy of any given basin is dependent on migrants from other basins in this region and possibly to the north while other basins to the south only sporadically harbor chinook salmon.

Table A.2.7.3. Geometric means, estimated lambda, and long- and short-term trends for abundance time series in the California Coastal Chinook Salmon ESU.

	5 year Geometric Mean			Trend	
	Rec	Min	Max	Long	Short
Freshwater Creek	22	13	22	0.137 (-0.405, 0.678)	0.137 (-0.405, 0.678)
Mad River					
Canon Creek	73	19	103	0.0102 (-0.106, 0.127)	0.155 (-0.069, 0.379)
Eel River					
Sprowl Creek	43	43	497	-0.096 (-0.157, -0.0336)	-0.183 (-0.356, -0.0096)
Tomki Creek	61	13	2,233	-0.199 (-0.351, -0.0464)	0.294 (0.0547, 0.533)

Humboldt Bay). None of these time series is especially suitable for analysis of trends or estimation of population growth rates. For this reason, we have presented the data graphically, and restricted analysis to estimation of long- and short-term trends, rather than pursue more sophisticated analysis.

Freshwater Creek—Counts of chinook salmon passing the weir near the mouth of Freshwater Creek, a tributary to Humboldt Bay, provide a proper census of a small (N ~ 20) population of naturally and hatchery-spawned chinook (Figure A.2.7.1). Chinook salmon occupying this watershed may be part of a larger "population" that uses tributaries of Humboldt Bay (NCCC-TRT, *in preparation*). The time series comprises only 8 years of observations, which is too few to draw strong inferences regarding trends. Clearly, the trend is positive, although the role of hatchery production in producing this signal may be significant (Table A.2.7.3; Figure A.2.7.1)

Mad River—Data for naturally spawning fish are available from spawner surveys on Canon Creek, and to a lesser extent on the North Fork Mad River. Only the counts from Canon Creek extend continuously to the present (Figure A.2.7.2a). Due to high variability in these counts, short-term and long-term trends do not differ significantly from zero, although the tendency is towards a positive trend. Due to a hypothesized, but unquantified, effect of interannual variation in water availability on distribution of spawners in the basin, it is not clear whether these data provide any useful information for the population as a whole; however, more sporadic counts from the mainstem Mad River suggest that the estimates from Canon Creek capture gross signals, and support the hypothesis of a recent positive trend in abundance (Figure A.2.7.2b).

Eel River—The Eel River plausibly harbors anywhere from one to five independent populations (NCCC-TRT, *in preparation*, Table A.2.7.2). Three current time series provide information for the population(s) that occupy this basin: (1) counts of adults reaching Van Arsdale Fish Station near the effective headwater terminus of the Eel River (Figure A.2.7.3a); (2) spawner surveys on Sprowl Creek (tributary to the Eel River) (Figure A.2.7.3b); and (3) spawner surveys on Tomki Creek (tributary to the Eel River) (Figure

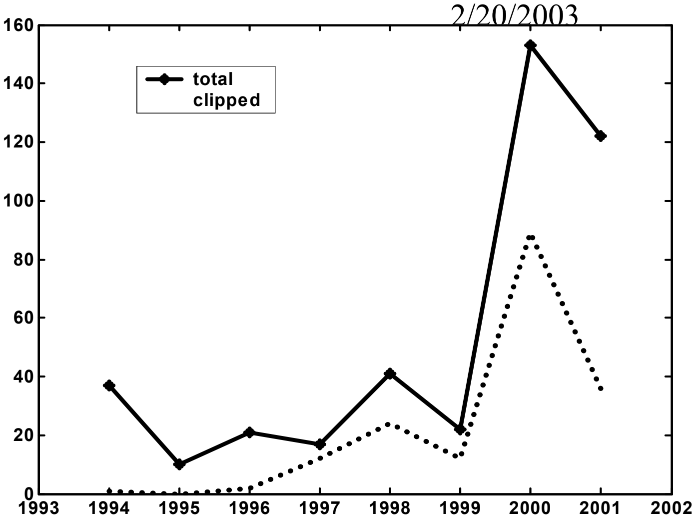
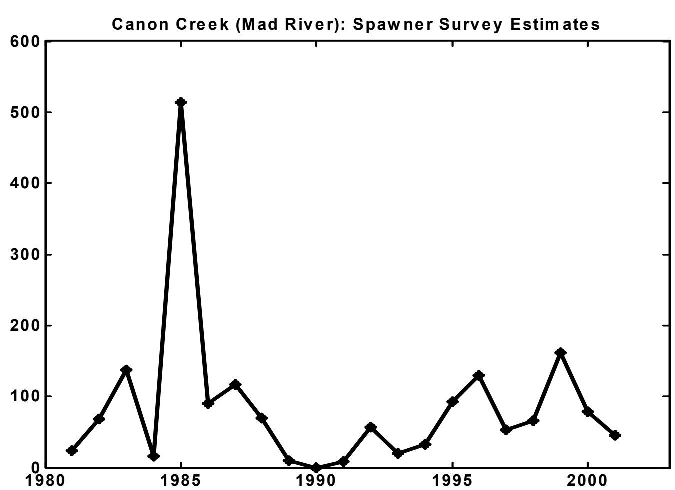


Figure A.2.7.1. Counts of chinook salmon at the weir on Freshwater Creek.

a



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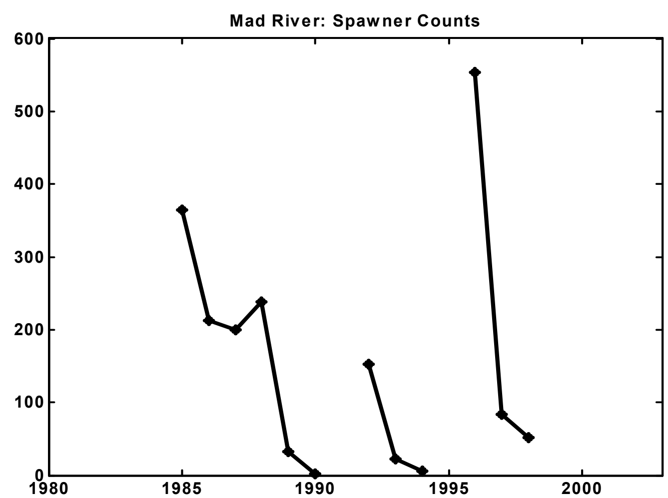

Figure A.2.7.2. Abundance time series for chinook salmon in portions of the Mad River basin. (a) spawner counts on Canon Creek; and (b) spawner counts on portions of the mainstem Mad River.

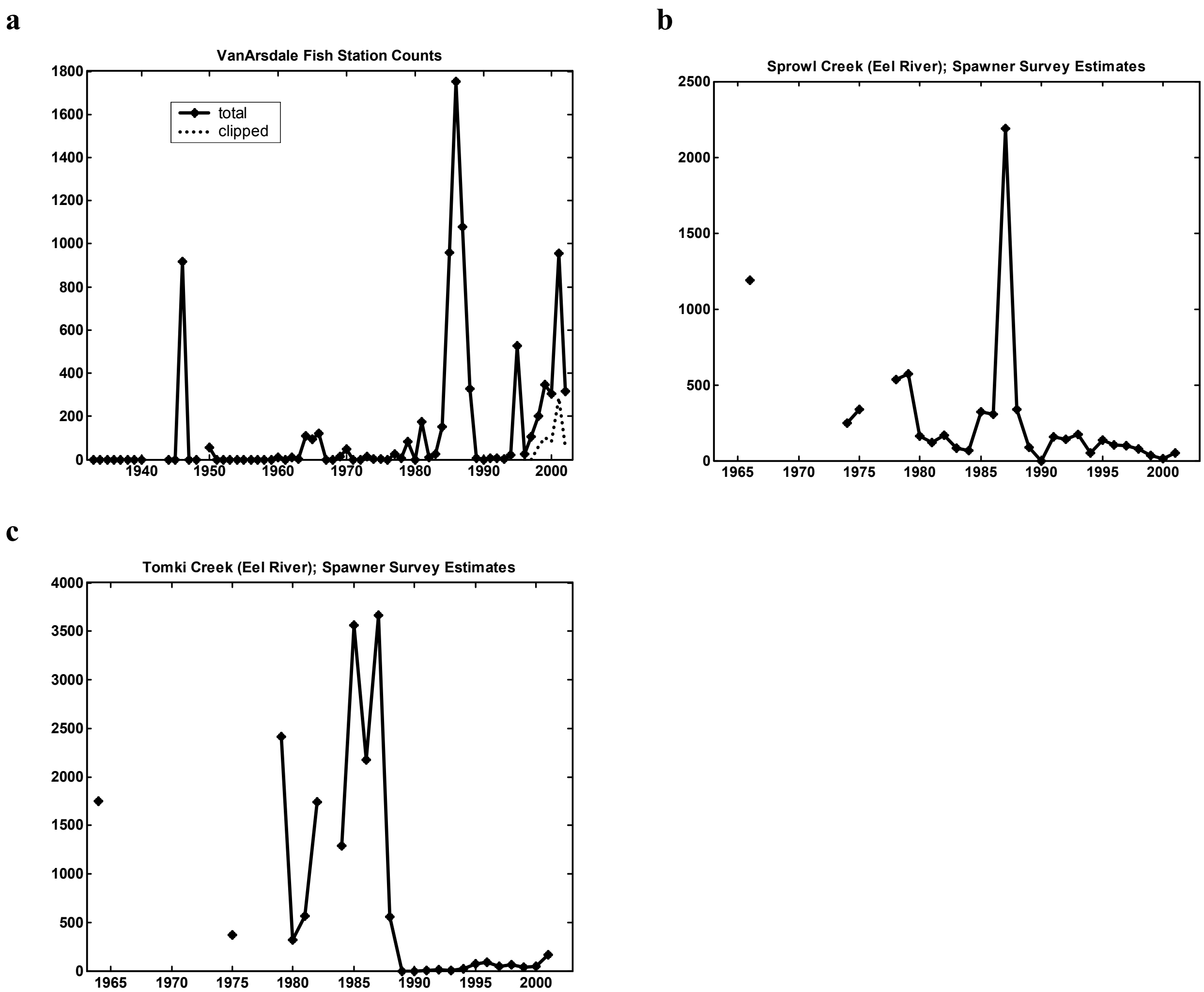

Figure A.2.7.3. Abundance time series for chinook salmon in portions of the Eel River basin. (a) counts of chinook salmon at Van Arsdale Fish Station at the upstream terminus of anadromous access on the mainstem Eel River; (b) estimates of spawner abundance based on spawner surveys and additional data from Sprowl Creek; and (c) estimates of spawner abundance based on spawner surveys and additional data from Tomki Creek.

A.2.7.3c). These data are not especially suited to rigorous analysis of population status for a number of reasons, and sophisticated analyses were not pursued.

Inferences regarding population status drawn from the time series of counts of adult chinook salmon reaching Van Arsdale Fish Station (VAFS) are weakened by two characteristics of the data. First, adult salmon reaching VAFS include both naturally and hatchery spawned fish, yet the long-term contribution of hatchery production to the spawner population is unknown and may be quite variable due to sporadic operation of the egg-take and release programs since the mid-1970's. Second, and perhaps more importantly, it is not clear what counts of natural spawners at VAFS indicate about the population or populations of chinook salmon in the Eel River. As a weir count, measurement error is expected to be small for these counts. However, very little spawning habitat exists above VAFS, which sits just below the Cape Horn dam on the Eel River, which suggests that counts made at VAFS represent the upper edge of the spawners' distribution in the upper Eel River. Spawner access to VAFS and other headwater habitats in the Eel River basin is likely to depend strongly on the timing and persistence of suitable river flow, which suggests that a substantial component of the process error in these counts is not due to population dynamics. For these reasons, no statistical analysis of these data was pursued.

Additional data for the Eel River population or populations are available from spawner surveys from Tomki and Sprowl Creeks, which yield estimates of abundance based on (1) quasi-systematic index site spawner surveys that incorporate mark-recapture of carcasses and (2) additional so-called "compatible" data from other surveys. Analysis for Sprowl Creek indicates negative long-term and short-term trends; similar analysis indicates a long-term decline and short-term increase for Tomki Creek (Table 3). Caution in interpreting these results is warranted, particularly given the quasi-systematic collection of these data, and the likelihood that these data include unquantified variability due to flow-related changes in spawners' use of mainstem and tributary habitats. In particular, inferences regarding population status based on extrapolations from these data to basin-wide estimates of abundance are expected to be weak and perhaps not warranted.

Mattole River—Recent spawner and redd surveys on the Mattole River and tributaries have been conducted by the Mattole Salmon Group since 1994. The surveys provide useful information on the distribution of salmon and spawning activity throughout the basin. Local experts have used these and ancillary data to develop rough "index" estimates of spawner escapement to the Mattole; however, the intensity and coverage of these surveys has not been consistent, and the resulting data are not suitable for rigorous estimation of abundance (e.g., through area-under-the-curve analysis).

Russian River—No long-term, continuous time series are available for sites in the Russian River basin, but sporadic estimates based on spawner surveys are available for some tributaries. Video-based counts of upstream migrating adult chinook salmon passing a temporary dam near Mirabel on the Russian River are available for 2000-2002. Counts are incomplete, due to technical difficulties with the video apparatus, occasional periods of poor water clarity, occasional overwhelming numbers of fish, and disparities between counting and migration periods; thus, these data represent a minimum count of adult chinook. Counts have exceeded 1,300 fish in each of the last three years (5,465 in 2002); and a rigorous mark-recapture estimate of outmigrant abundance in 2002 exceeded 200,000 (Shawn Chase, Sonoma County Water Agency, *personal communication*). Since chinook salmon have not been produced at the Don Clausen Hatchery since 1997, so these counts represent natural production or straying from other systems. No data were available to assess the genetic relationship of these fish to others in this or other ESUs.

Summary—Historical and current information indicates that abundance in putatively independent populations of chinook salmon is depressed in many of those basins where they have been monitored. The relevance of recent strong returns to the Russian River to ESU status are not clear as the genetic composition of these fish is unknown. Reduction in geographic distribution, particularly for spring-run chinook salmon and for basins in the southern portion of the range, continues to present substantial risk. Genetic concerns are reviewed below (Hatchery Information). As for previous status reviews, uncertainty continues to contribute substantially to assessments of risk facing this ESU.

A.2.7.3 Hatchery Information

Hatchery stocks that are being considered for inclusion in this ESU are: (1) Mad River Hatchery, (2) hatchery activities of the Humboldt Fish Action Council on Freshwater Creek; (3) Yager Creek Hatchery operated by Pacific Lumber Company; (4) Redwood Creek Hatchery; (5) Hollow Tree Creek Hatchery; (6) Van Arsdale Fish Station; and (6) hatchery activities of the Mattole Salmon Group. Chinook salmon are no longer produced at the Don Clausen hatchery on Warm Springs Creek (Russian River). In general, hatchery programs in this ESU are not oriented towards large-scale production, but rather are small-scale operations oriented at supplementing depressed populations.

Freshwater Creek—This hatchery is operated by Humboldt Fish Action Council and CDFG to supplement and restore natural production in Freshwater Creek. All spawners are from Freshwater Creek; juveniles are marked and hatchery fish are excluded from use as broodstock. Weir counts provide good estimates of the proportion of hatchery- and naturally produced fish returning to Freshwater Creek (30-70% hatchery from 1997-2001); the contribution of HFAC production to spawning runs in other streams tributary to Humboldt Bay is unknown.

Mad River—Recent production from this hatchery has been based on small numbers of spawners returning to the hatchery. There are no estimates of naturally spawning chinook salmon abundance available for the Mad River to determine the contribution of hatchery production to chinook salmon in the basin as a whole. Broodstock has generally been drawn from chinook salmon returning to the Mad River; however, releases in the 1970s and 1980s have included substantial releases of fish from out-of-basin (Freshwater Creek) and out-of-ESU (Klamath-Trinity and Puget Sound).

Eel River—Four hatcheries, none of which are major production hatcheries, contribute to production of chinook salmon in the Eel River Basin: hatcheries on Yager Creek (recent effort: ~12 females spawned per year), Redwood Creek (~12 females), Hollow Tree Creek, and the Van Arsdale Fish Station (VAFS) (~60 males and females spawned). At the first three hatcheries, broodstock is selected from adults of non-hatchery origin; at VAFS, broodstock includes both natural and hatchery origin fish. In all cases, however, insufficient data on naturally spawning chinook salmon are available to estimate the effect of hatchery fish on production or other characteristics of naturally spawning chinook salmon in the Eel River basin. Since 1996, all fish released from VAFS have been marked. Subsequent returns indicate that approximately 30% of the adult chinook salmon trapped at VAFS are of hatchery origin. It is not clear what these numbers indicate about hatchery contributions to the population of fish spawning below VAFS.

Mattole River—The Mattole Salmon Group has operated a small hatchbox program since 1980 (current effort: ~40,000 eggs from ~10 females) to supplement and restore chinook salmon and other salmonids in the Mattole River. All fish are marked, but no rigorous estimate of hatchery contributions to adult escapement is possible. Hatchery-produced outmigrants comprised approximately 17.3% (weighted average) of outmigrants trapped during 1997, 1998 and 2000 (Mattole Salmon Group 2000, Five Year Management Plan for Salmon Stock Rescue Operations 2000-2001 through 2004-2005 Seasons). Trapping efforts did not fully span the period of natural outmigration so this figure may overerestimate the contribution of hatch-box production to total production in the basin.

Russian River—Production of chinook salmon at the Don Clausen (Warm Springs Hatchery) ceased in 1997 and had been largely ineffective for a number of years prior to that. Recent returns of chinook salmon to the Russian River stem from natural production, and possibly from fish straying from other basins, including perhaps Central Valley stocks.

Summary

Artificial propagation of chinook salmon in this ESU remains at relatively low levels. No putatively independent populations of chinook salmon in this ESU appear to be entirely dominated by hatchery production, although proportions of hatchery fish can be quite high where natural escapement is small and hatchery production appears to be successful (e.g., Freshwater Creek). It is not clear whether current hatcheries pose a risk or offer a benefit to naturally spawning populations. Extant hatchery programs are operated under guidelines designed to minimize genetic risks associated with artificial propagation, and save for historical inputs to the Mad River Hatchery stock, do not appear to be at substantial risk of incorporating out-of-basin or out-of-ESU fish. Thus, it is likely that artificial propagation and degradation of genetic integrity continue do not represent a substantial conservation risk to the ESU. Categorizations of hatchery stocks in the California Coastal chinook ESU (SSHAG 2003) can be found in Appendix A.5.1.

A.2.7.4 Comparison with Previous Data

Few new data, and few new datasets were available for consideration, and none of the recent data contradict the conclusions of previous status reviews. Chinook salmon in the Coastal California ESU continue to exhibit depressed population sizes relative to historical abundances; this is particularly true for spring-run chinook, which may no longer be extant anywhere within the range of the ESU. Evaluation of the significance of recent potential increases in abundance of chinook salmon in the Russian River must weigh the substantial uncertainty regarding the genetic relatedness of these fish to others in the northern part of the ESU.

Harvest rates are not explicitly estimated for this ESU; however, it is likely that current restrictions on harvest of Klamath River fall chinook maintain low ocean harvest of chinook salmon from the California Coastal ESU (PFMC 2002a, b). Potential changes in age-structure of chinook salmon populations (e.g., Hankin et al. 1993) and associated risk has not been evaluated for this ESU.

No information exists to suggest new risk factors, or substantial effective amelioration of risk factors noted in the previous status reviews save for recent changes in ocean conditions. Recent favorable ocean conditions have contributed to apparent increases in abundance and distribution for a number of anadromous salmonids, but the expected persistence of this trend is unclear.

A.2.8. SACRAMENTO RIVER WINTER-RUN CHINOOK

A.2.8.1. Previous BRT Conclusions

Summary of major risk factors and status indicators

Historically, winter chinook were dependent on access to spring-fed tributaries to the upper Sacramento River that stayed cool during the summer and early fall. Adults enter freshwater in early winter and spawn in the spring and summer. Juveniles rear near the spawning location until at least the fall, when water temperatures in lower reaches are be suitable for migration. Winter chinook were abundant and comprised populations in the McCloud, Pit, and Little Sacramento, with perhaps smaller populations in Battle Creek and the Calaveras River. On the basis of commercial fishery landings in the 1870s, Fisher (1994) estimated that the total run size of winter chinook may have been 200,000 fish.

The most obvious challenge to winter chinook was the construction of Shasta Dam, which blocked access to the entire historic spawning habitat. It was not expected that winter chinook would survive this habitat alteration (Moffett 1949). Cold-water releases from Shasta, however, created conditions suitable for winter chinook for roughly 100 km downstream from the dam. Presumably, there were several independent populations of winter chinook in the Pitt, McCloud, Little Sacramento Rivers and various tributaries to these rivers such as Hat Creek and the Fall River, and these populations merged to form the present single population. If there ever were populations in Battle Creek and the Calaveras River, they have been extirpated.

In addition to having only a single extant population dependent on artificially-created conditions, winter chinook face numerous other threats. Chief among these is small population size: escapement fell below 200 fish in the 1980s. Population size declined monotonically from highs of near 100,000 fish in the late 1960s, indicating a sustained period of poor survival. There are questions of genetic integrity due to winter chinook having passed through several bottlenecks in the 20th century. Other threats include inadequately screened water diversions, predation at artificial structures and by nonnative species, overfishing, pollution from Iron Mountain mine (among other sources), adverse flow conditions, high summer water temperatures, unsustainable harvest rates, passage problems at various structures (especially, until recently, Red Bluff Diversion Dam), and vulnerability to drought.

BRT conclusions

The chinook BRT spent little time considering the status of winter chinook, because winter chinook were already listed as endangered at the time of previous BRT meetings.

Listing status

Winter chinook were listed as Threatened in 1990 and reclassified as Endangered 1994.

A.2.8.2 Summary of New Information

Viability assessments

Two studies have been done on the population viability of Sacramento River winter chinook. Botsford and Brittnacher, (1998), in a paper that is part of the draft recovery plan, developed de-listing criteria using a simple age-structured, density-independent model of spawning escapement. They concluded, on the basis of the 1967-1995 data, that winter chinook were certain to fall below the quasi-extinction threshold of 3 consecutive spawning runs with less than 50 females.

Lindley and Mohr, (in press) developed a slightly more complex Bayesian model of winter chinook spawning escapement that allowed for density dependence and a change in population growth rate in response to conservation measures initiated in 1989. This model, due to its allowance for the growth rate change, its accounting for parameter uncertainty, and use of newer data (through 1998), suggested a lower but still biologically significant expected quasi-extinction probability of 28%.

Draft recovery plan

The draft recovery plan for winter chinook (NMFS 1997) provides a comprehensive review of the status, life history, habitat requirements, and risk factors of winter chinook. It also provides a recovery goal: an average of 10,000 females spawners per year and a $\lambda \geq 1.0$ calculated over 13 years of data (assuming a certain level of precision in spawning escapement estimates).

New abundance data

The winter chinook spawning run has been counted at Red Bluff Diversion Dam (RBDD) fish ladders since 1967. Escapement has been estimated with a carcass survey since 1997. Through the mid-1980s, the RBDD counts were very reliable. At that time, changes to the dam operation were made to alleviate juvenile and adult passage problems. Now, only the tail end of the run (about 15% on average) is forced over the ladders, greatly reducing the accuracy of the RBDD counts. The carcass mark-recapture surveys were initiated to improve escapement estimates. The two measures are in very rough agreement, and there are substantial problems with both estimates, making it difficult to choose one as more reliable than the other. It does appear that the RBDD count is an underestimate, since the carcass survey crews have handled more carcasses than the RBDD estimate in some years, and only a fraction of the carcasses are available for capture. The problem with the carcass-based estimate is the estimation of this fraction—it appears that the probability of initial carcass recovery depends strongly on the sex of the fish and possibly on whether it has been previously recovered. In spite of these problems, both abundance measures suggest that the abundance of winter chinook is increasing. Based on the RBDD counts, the winter chinook population has been growing rapidly since the early 1990s (Figure A.2.8.1), with a short-term trend of 0.26 (Table A.2.8.1). On the population growth rate-population size space, the winter chinook population has a somewhat low population growth and moderate size compared to other Central Valley salmonid populations (Figure A.2.8.2).

Table A.2.8.1. Summary statistics for trend analyses. Numbers in parentheses are 0.90 confidence intervals

Population	5-yr mean	5-yr min	5-yr max	λ	μ	LT trend	ST trend
Sac. R. winter chinook	2,191	364	65,683	0.97 (0.87, 1.09)	-0.10 (-0.21, 0.01)	-0.14 (-0.19, -0.09)	0.26 (0.04, 0.48)
Butte Cr. spring chinook	4,513	67	4,513	1.30 (1.09, 1.60)	0.11 (-0.05, 0.28)	0.11 (0.03, 0.19)	0.36 (0.03, 0.70)
Deer Cr. spring chinook	1,076	243	1,076	1.17 (1.04, 1.35)	0.12 (-0.02, 0.25)	0.11 (0.02, 0.21)	0.16 (-0.01, 0.33)
Mill Cr. spring chinook	491	203	491	1.19 (1.00, 1.47)	0.09 (-0.07, 0.26)	0.06 (-0.04, 0.16)	0.13 (-0.07, 0.34)
Sac. R. steelhead	1,952	1,425	12,320	0.95 (0.90, 1.02)	-0.07 (-0.13, 0.00)	-0.09 (-0.13, -0.06)	-0.06 (-0.26, 0.15)

Winter chinook may be responding to a number of factors, including wetter-than-normal winters, reduced harvest, changes in RBDD operation, installation of a cold-water release device on Shasta Dam, changes in operations of the state and federal water projects, and a variety of other habitat improvements. While the status of winter chinook is improving, there is only one winter chinook population and it is dependent on cold-water releases of Shasta Dam, which could be vulnerable to a prolonged drought. The recent 5-year geometric mean is only 3% of the maximum post-1967 5-year geometric mean.

The RBDD counts are suitable for modeling as a random-walk-with-drift (also known as the "Dennis model" [Dennis et al., 1991]). In the RWWD model, population growth is described by exponential growth or decline:

$$N_{t+1} = N_t \exp(\mu + \eta_t), \tag{1}$$

where N_t is the population size at time t, μ is the mean population growth rate, and η_t is a normal random variable with mean=0 and variance = σ^2_p.

Table A.2.8.2. Parameter estimates for the constant-growth and step-change models applied to winter chinook. Numbers in parentheses indicate 90% confidence intervals.

	model	
parameter	constant □	step change □
μ	˜0.085	˜0.214
	˜0.181,0.016	˜(0.322˜,0.113)
δ	NA	0.389
	NA	(0.210, 0.574)
σ^2_p	0.105	0.056
	(0.0945, 0.122)	(0.046, 0.091)
σ^2_m	0.0025	0.011
	(2.45×10^6, 0.0126)	(3.92×10^6, 0.022)
P_{100}(ext)[a]	0.40	0.003
	(0.00, 0.99)	(0.0, 0.0)

[a] Probability of extinction (pop. size < 1 fish) within 100 years.

The RWWD model, as written in Equation 1, ignores measurement error. Observations (y_t) can be modeled separately,

$$y_t = N_t \exp(\varepsilon_t), \qquad (2)$$

where ε_t is a normal random variable with mean = 0 and variance = σ^2_m. Equations 1 and 2 together define a state-space model that, after linearizing by taking logarithms, can be estimated using the Kalman filter (Lindley, in press).

A recent analysis of the RBDD data (Lindley and Mohr, in press) indicated that the population growth since 1989 was higher than in the preceding period. For this reason, I fit two forms of the RWWD model- one with a fixed growth rate (constant-growth model) and another with a growth rate with a step-change in 1989, when conservation actions began (step-change model, $\mu_t = \mu$ for $t < 1989$, $\mu_t = \mu + \delta$ for $t \geq 1989$). In both cases, a 4-year running sum was applied to the spawning escapement data to form a total population estimate (Holmes, 2001). Results of model fitting are shown in Table A.2.8.2. The constant-growth model satisfies all model diagnostics, although visual inspection of the residuals shows a strong tendency to under-predict abundance in the most recent 10 years. The residuals of the step-change model fail the Shapiro-Wilks test for normality; the residuals look truncated on the positive side, meaning that good years are not as extreme as bad years. Winter chinook growth rate might be better modeled as a mixture between a normal distribution and another distribution reflecting near-catastrophic population declines caused by episodic droughts.

According to Akaike's information criterion (AIC), the step-change model is a much better approximation to the data than the constant population growth rate model, with an AIC difference of 9.61 between the two models (indicating that the data provide almost no support for the constant-growth model). The step-change model suggests the winter chinook population currently has a λ of 1.21, while for the constant population growth rate model, $\lambda = 0.97$[4]. The extinction risks predicted by the two models are extremely different: winter chinook have almost no risk of extinction if the apparent recent increase in λ holds in the future, but are certain to go extinct if the population grows at its average rate, with a most likely time of extinction being 100 years. While it would be dangerous to assume that recent population growth will hold indefinitely, it does appear that the status of winter chinook is improving.

Harvest impacts

Substantial changes in ocean fisheries off central and northern California have occurred since the last status review (PFMC 2002a, b). Ocean harvest rate of winter chinook is thought to be a function of the Central Valley chinook ocean harvest index (CVI), which is defined as the ratio of ocean catch south of Point Arena to the sum of this catch and the escapement of chinook to Central Valley streams and hatcheries. Note that other stocks (e.g., Klamath chinook) contribute to the catch south of Point Arena. This harvest index ranged from 0.55 to nearly 0.80 from 1970 to 1995, when harvest regimes were adjusted to protect winter chinook. In 2001, the CVI fell to 0.27. The reduction in harvest is presumably at least partly responsible for the record spawning escapement of fall chinook (≈ 540,000 fish in 2001).

Because they mature before the onset of the ocean fishing season, winter chinook should have lower harvest rates than fall chinook. At the time of the last status review, the only information of the harvest rate of winter chinook came from a study conducted in the 1970s. The impact rate (direct and indirect effects of harvest) of ocean fisheries on winter chinook was estimated to be 0.54, and the river sport fishery at that time was thought to have an impact rate of 0.08.

The recent release of significant numbers of ad-clipped winter chinook provides new, but limited, information on the harvest of winter chinook in coastal recreational and troll fisheries. The 1998 brood year was the first brood to have sufficient tag releases. Dan Viele (Sustainable Fisheries, SWR) conducted a cohort reconstruction of the 1998 broodyear. Winter chinook are mainly vulnerable to ocean fisheries as 3-year olds. Viele calculated, on the basis of 123 coded-wire-tag recoveries, that the ocean fishery impact rate on 3-year-olds is 0.21 and the in-river sport fishery impact rate is 0.24. For a given year, these fisheries combine to reduce spawning escapement by about 43%. The high estimated rate of harvest in the river sport fishery, which arises from the recovery of 8 coded-wire tags, was a surprise, because salmon fishing is closed from January 15 to July 31 to protect winter-run chinook. The tags were recovered in late December/early January, at the tail end of the fishery for late-fall chinook. The estimate of river sport fishery impact is much less certain than the ocean fishery impact estimate because of the lower number of tag recoveries, less rigorous tag sampling, and larger expansion factors. Never the less, in response to this information, the California Fish and Game Commission is moving

[4]In this section of the document □ is defined as $\exp(\mu + \sigma^2_p / 2)$, the *mean* annual population growth rate.

forward with an emergency action to amend sport fishing regulations to ban retention of salmon caught in river sport fisheries on January 1 rather than January 15. Had such regulations been in place in 1999/2000, the harvest rate would have been 20% of that observed.

New hatchery information

Livingston Stone National Fish Hatchery (LSNFH) was constructed at the base of Shasta Dam in 1997, with the sole purpose of helping to restore natural production of winter chinook. LSNFH was designed as a conservation hatchery with features intended to overcome the problems of CNFH (better summer water quality, natal water source). All production is ad-clipped. Each individual considered for use as broodstock is genotyped to ensure that it is a winter chinook. No more than 10% of the broodstock is composed of hatchery origin fish, and no more than 15% of the run is taken for broodstock, with a maximum of 120 fish. Figure 3 shows the number of winter chinook released by CNFH/LSNFH; Figure 4 shows the returns to these hatcheries.

A.2.8.3 New Comments

The California State Water Contractors, the San Luis and Delta-Mendota Water Authority, and the Westlands Water District recommend that the listing status of winter chinook be changed from endangered to threatened. They base this proposal on the recent upturn of adult abundance, recently initiated conservation actions (restoration of Battle Creek, ocean harvest reductions, screening of water diversions, remediation of Iron Mountain Mine, and improved temperature control), and a putative shift in ocean climate in 1999.

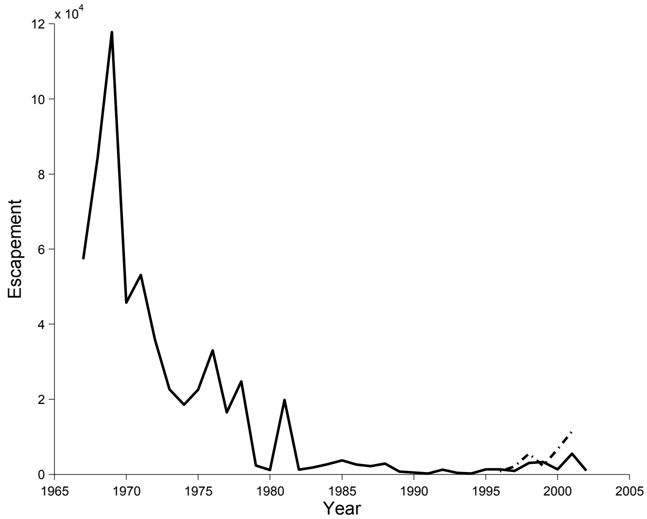

Figure A.2.8.1. Estimated winter chinook spawner abundance as determined by RBDD fish ladder (solid line) and carcass mark-recapture (dashed line).

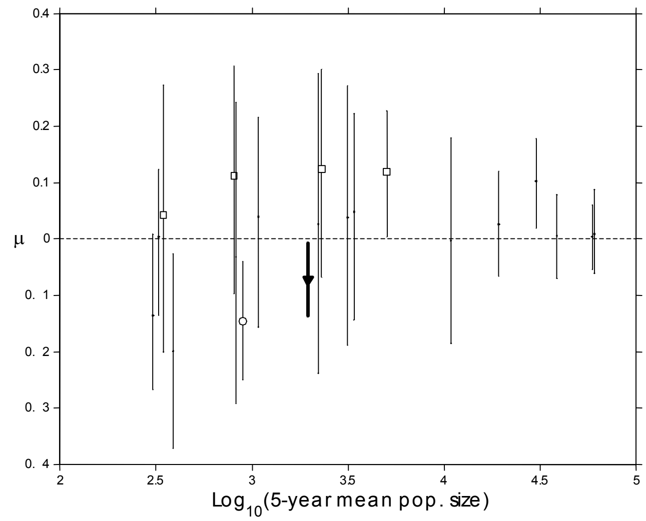

Figure A.2.8.2. Abundance and growth rate of Central Valley salmonid populations. Open circle- steelhead; open squares- spring chinook; filled triangle- winter chinook; small black dots- other chinook stocks. Error bars represent central 0.90 probability intervals for μ estimates. (Note: as defined in other sections of the status reviews, μ ≈ log(λ).)

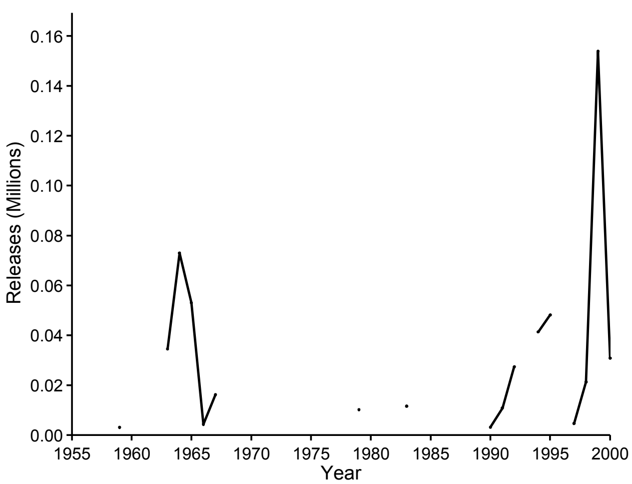

Figure A.2.8.3. Number of juvenile winter-run chinook released by Coleman and Livingston Stone National Fish Hatcheries.

Figure A.2.8.4. Number of adult winter-run chinook captured by Coleman and Livingston Stone National Fish Hatcheries.

A.2.9. CENTRAL VALLEY SPRING-RUN CHINOOK

A.2.9.1. Previous BRT Conclusions

Summary of major risk factors and status indicators

Threats to Central Valley (CV) spring chinook fall into three broad categories: loss of most historic spawning habitat, degradation of remaining habitat, and genetic threats from the Feather River Hatchery spring chinook program. Like most spring chinook, CV spring chinook require cool water while they mature in freshwater over the summer. In the Central Valley, summer water temperatures are suitable for chinook salmon only above 150-500m elevation, and most such habitat in the CV is now behind impassable dams (Figure A.2.9.1). Only three self-sustaining wild populations of spring chinook (on Mill, Deer and Butte creeks, tributaries to the lower Sacramento River draining out of the southern Cascades) are extant. These populations reached quite low abundance levels during the late 1980s (5-year mean population sizes of 67-243 spawners), compared to a historic peak abundance of perhaps 700,000 spawners for the ESU (estimate of Fisher [1994], based on catches in the early gill-net fishery). Of the numerous populations once inhabiting Sierra Nevada streams, only the Feather River and Yuba River populations remain, and these are apparently dependent on the Feather River Hatchery.

In addition to outright loss of habitat, CV spring chinook must contend with the widespread habitat degradation and modification of their rearing and migration habitats in the natal stream, the Sacramento River, and the Delta. The natal tributaries do not have large impassable dams like many Central Valley Streams, but they do have many small hydropower dams and water diversions that, in some years, have greatly reduced or eliminated in-stream flows during spring-run migration periods. Problems in the migration corridor include unscreened or inadequately screened water diversions, predation by non-native species, and excessively high water temperatures.

The Feather and Yuba Rivers contain populations thought to be significantly influenced by the Feather River Hatchery (FRH) spring chinook stock. The FRH spring chinook program releases its production far downstream of the hatchery, causing high rates of straying (CDFG 2001). There is concern that fall and spring chinook have hybridized in the hatchery. The BRT viewed FRH as a major threat to the genetic integrity of the remaining wild spring chinook populations.

BRT conclusions

In the original chinook status review, a majority of BRT concluded that the CV spring chinook ESU was in danger of extinction (Myers et al. 1998). Listing of this ESU was deferred, and in the status review update, the BRT majority shifted to the view that this ESU was not in danger of extinction, but was likely to become endangered in the foreseeable future (NMFS 1999). A major reason for this shift was data indicating that a large run of spring chinook on Butte Creek in 1998 was naturally produced, rather than strays from FRH.

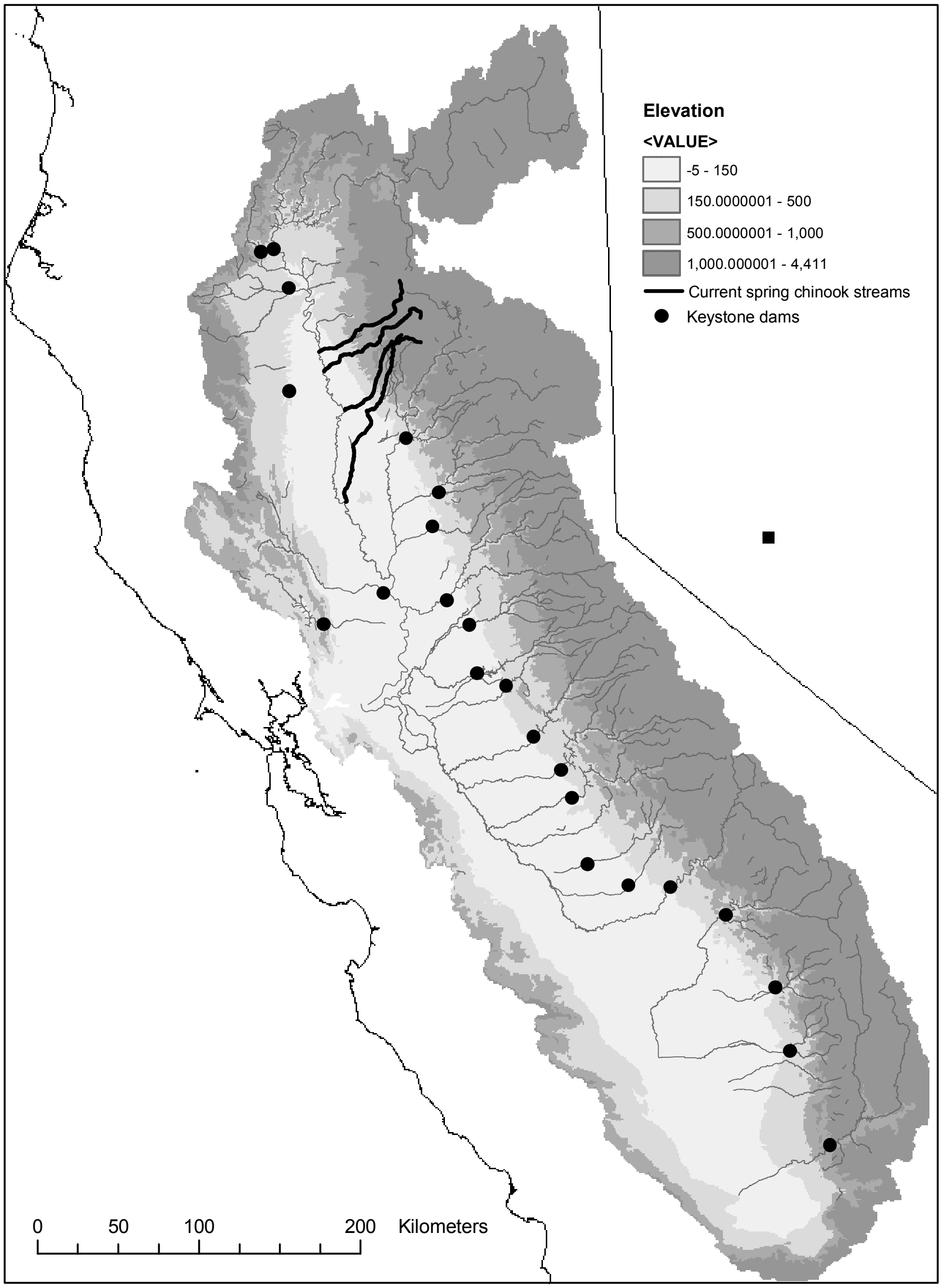

Figure A.2.9.1. Map of Central Valley showing the locations of self-sustaining spring chinook populations. These populations are found in the only watersheds with substantial accessible habitat above 500 m elevation.

Listing status

Central Valley spring chinook were listed as threatened in 1999. Naturally spawning spring chinook in the Feather River were included in the listing, but the Feather River Hatchery stock of spring chinook was excluded.

A.2.9.2 New Data

Status assessments

In 1998, CDFG reviewed the status of spring-run chinook in the Sacramento River drainage in response to a petition to list these fish under the California Endangered Species Act (CESA) (CDFG 1998). CDFG concluded that spring chinook formed an interbreeding population segment distinct from other chinook salmon runs in the Central Valley. CDFG estimated that peak run sizes might have exceeded 600,000 fish in the 1880s, after substantial habitat degradation had already occurred. They blame the decline of spring chinook on the early commercial gillnet fishery, water development that blocked access to headwater areas, and habitat degradation. Current risks to the remaining populations include continued habitat degradation related to water development and use, and the operation of FRH. CDFG recommended that Sacramento River spring-run chinook be listed as threatened under the CESA.

Population structure

There are preliminary results for two studies of spring chinook population structure. Two important insights are provided by these data sets. First, CV spring chinook do not appear to be monophyletic, yet wild CV spring chinook populations from different basins are more closely related to each other than to fall chinook from the same basin. Second, neither Feather River natural (FR) or Feather River Hatchery (FRH) spring chinook are closely related to any of the three wild populations although they are closely related to each other and to CV fall chinook.

David Teel of the NWFSC used allozymes to show that Butte and Deer creek spring chinook are not closely related to sympatric fall chinook populations or the FRH spring chinook stock (Figure A.2.9.2). FRH spring chinook, putative Feather River natural spring chinook, and Yuba River spring chinook fell into a large cluster composed mostly of natural and hatchery fall chinook.

Dennis Hedgecock and colleagues, using 12 microsatellite markers, showed that there are two distinct populations of chinook in the Feather River (Hedgecock 2002). One population is formed by early-running ("spring") chinook, the other by late running fish ("fall run"). Once run timing was accounted for, hatchery and naturally spawning fish appear to form a homogeneous population. The Feather River spring population is most closely related to FR fall (F_{st}=0.010) and to Central Valley Fall chinook (F_{st}=0.008) and is distinct from spring chinook in Deer, Mill (F_{st}=0.016) and Butte (F_{st}=0.034) creeks. Figure A.2.9.3 shows the neighbor-joining tree with Cavalli-Sforza and Edwards chord distances and unweighted pair-group method arithmetic averaging.

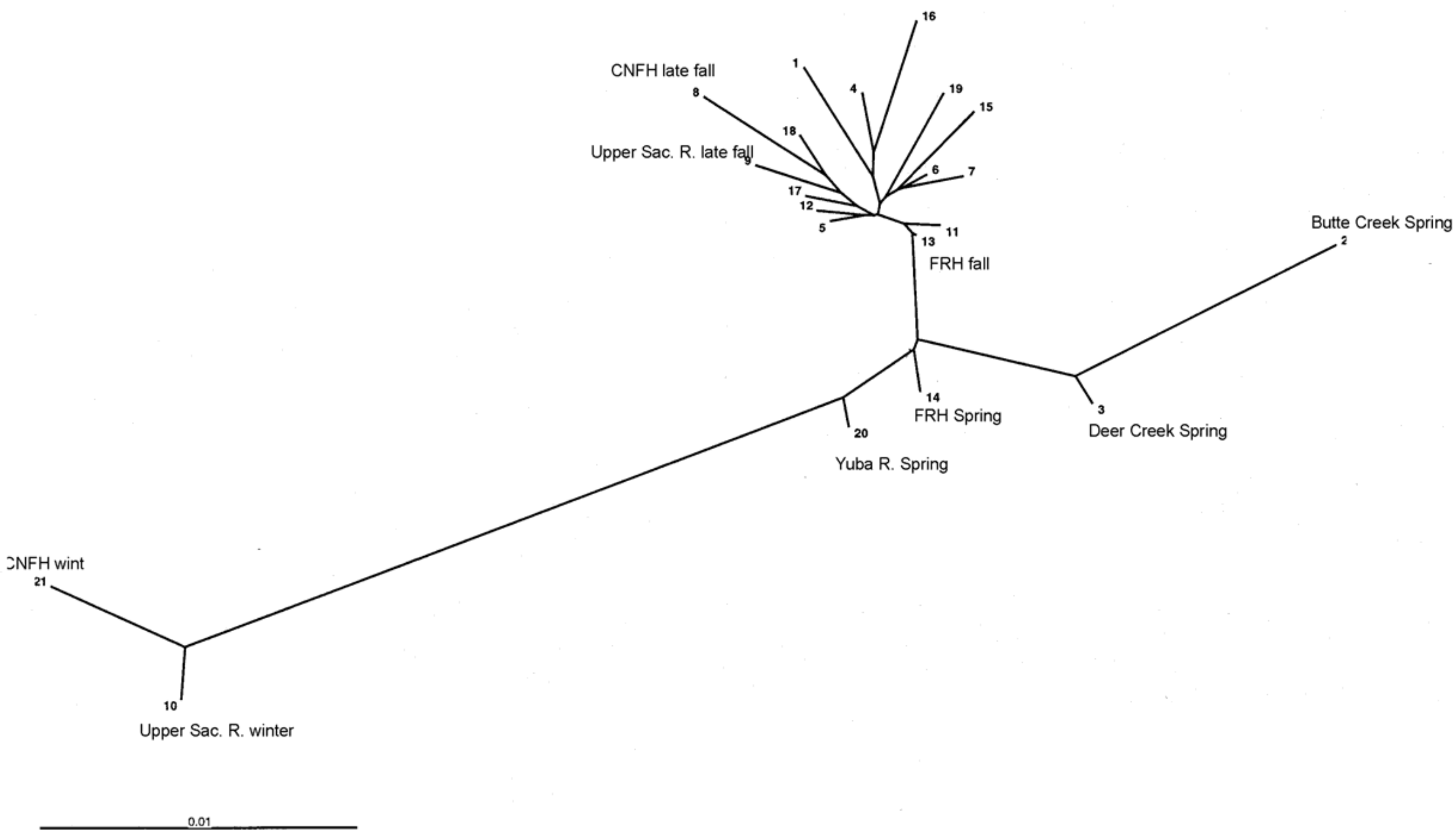

Figure A.2.9.2. Neighbor joining tree (Cavalli-Sforza and Edwards chord distances) for Central Valley chinook populations, based on 24 polymorphic allozyme loci (unpublished data from D. Teel, NWFSC). Populations labeled with only a number are various fall chinook populations.

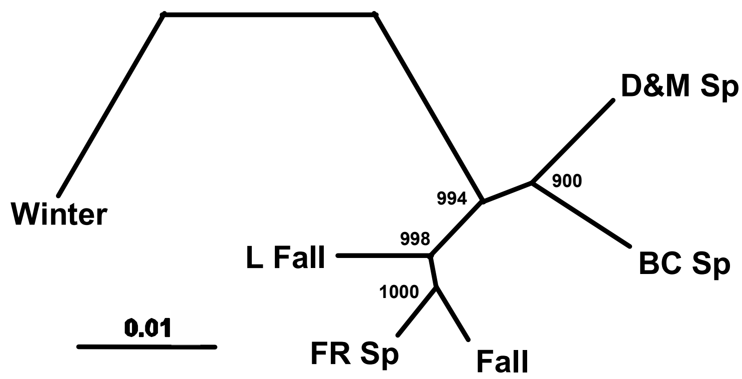

Figure A.2.9.3. Neighbor joining tree (Cavalli-Sforza and Edwards chord distances) for Central Valley chinook populations, based on 12 microsatellite loci. D&M = Deer and Mill Creek; BC = Butte Creek; FR = Feather River; Sp= spring chinook; L Fall = late-fall chinook; Winter = winter chinook. The tree was constructed using Cavalli-Sforza and Edwards measure of genetic distance and the unweighted pair-group method arithmetic averaging. Figure from Hedgecock (2002).

At least two hypotheses could explain the Feather River observations:

1. an ancestral Mill/Deer/Butte-type spring chinook was forced to hybridize with the fall chinook, producing an intermediate form.
2. the ancestral Feather River spring chinook had a common ancestor with the Feather River fall chinook, following the pattern seen in Klamath chinook but different from the pattern seen in Deer, Butte and Mill creeks. The FR and FRH populations have merged.

Hedgecock argues against the first hypothesis. Feather River fish cluster well within Central Valley fall chinook rather than between Mill/Deer/Butte spring chinook and Central Valley fall chinook, as would be expected under hypothesis 1. Furthermore, there is no evidence from linkage disequilibria that FR spring and FR fall populations are hybridizing, i.e., these populations are reproductively isolated. It is perhaps not surprising that Feather River spring chinook might have a different ancestry than spring chinook in Mill, Deer and Butte creek, since the Feather River is in a different ecoregion.

Regardless of the cause of the genetic patterns described above, these new data do not support the current configuration of the CV spring chinook ESU. Feather River spring chinook do not appear to share a common ancestry or evolutionary trajectory with other spring chinook populations in the Central Valley. They share the designation of “spring” chinook, and indeed, the Feather River and FRH have a chinook spawning run that starts much earlier than other Sacramento basin rivers. There is no longer a distinct bimodal distribution to run timing, however, and substantial fractions of fish released as FRH spring chinook have returned during the fall chinook period (and vice versa) (CDFG 1998). If FR and FRH spring chinook are retained in the CV spring chinook ESU, then the ESU configuration of the CV fall-late fall chinook ESU (among several others) should be reconsidered for the sake of consistency, because late-fall chinook are more distinct genetically and arguably as distinct in terms of life history as FRH spring chinook.

Historic habitat loss

Yoshiyama and colleagues detailed the historic distribution of Central Valley spring chinook. Yoshiyama et al. (2001) estimated that 72% of salmon spawning and rearing habitat has been lost in the Central Valley. This figure is for fall as well as spring chinook, so the amount of spring chinook habitat lost is presumably higher, because spring chinook spawn and rear in higher elevations, areas more likely to be behind impassable dams. They deem the 95% loss estimate of CDFG (Reynolds et al. 1993) as "perhaps somewhat high but probably roughly accurate."

Life history

CDFG recently began intensive studies of Butte Creek spring chinook (Ward et al. 2002). One of the more interesting observations is that while most spring chinook leave Butte Creek as young-of-the-year, yearling outmigrants make up roughly 25% of the ocean catch of Butte Creek spring chinook.

New harvest information

Coded-wire tagging of juvenile spring chinook in Butte Creek provides some limited information on current harvest rates of this population. Based on eight CWT recoveries in the ocean fisheries and 15 CWT recoveries in Butte Creek, the harvest rate on age 3 Butte Creek spring chinook is 0.44 (Ward et al. 2002).

Substantial changes in ocean fisheries off central and northern California have occurred since the last status review (PFMC 2002a, b). Ocean harvest rate of Central Valley spring chinook is thought to be a function of the Central Valley chinook ocean harvest index (CVI), which is defined as the ratio of ocean catch south of Point Arena to the sum of this catch and the escapement of chinook to Central Valley streams and hatcheries. Note that other stocks (e.g., Klamath chinook) contribute to the catch south of Point Arena. This harvest index ranged from 0.55 to nearly 0.80 from 1970 to 1995, when harvest regimes were adjusted to protect winter chinook. In 2001, the CVI fell to 0.27. The reduction in harvest is presumably at least partly responsible for the record spawning escapement of fall chinook ($\approx$ 540,000 fish in 2001).

A.2.9.3 New Comments

The State Water Contractors (SWC) submitted several documents, one of them relevant to the status review for CV spring chinook. The document, "Reconsideration of the listing status of spring-run chinook salmon within the Feather River portion of the Central Valley ESU," argues that Feather River spring chinook should not be included in the Central Valley spring chinook ESU and do not otherwise warrant protection under the ESA. SWC also suggested that NOAA Fisheries conduct a series of evaluations of the following topics:

1. impact of hatchery operations on the population dynamics and the genetic integrity of natural stocks
2. hatcheries as conservation

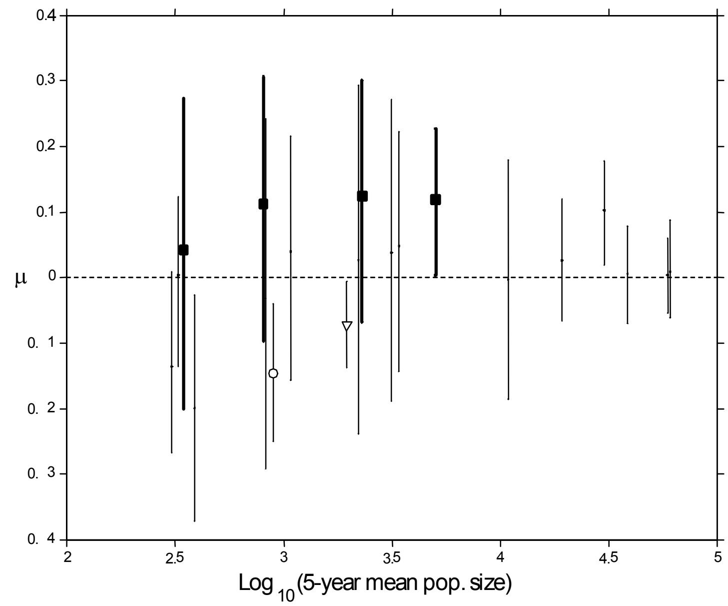

Figure A.2.9.4. Abundance and growth rate of Central Valley salmonid populations. Open circle- steelhead; filled squares- spring chinook; open triangle- winter chinook; small black dots- other chinook stocks (mostly fall runs). Error bars represent central 0.90 probability intervals for μ estimates. (Note: as defined in other sections of the status reviews, $\mu \approx \log [\lambda]$.)

3. effects of mixed-stock fisheries
4. assessment of the relative roles of different mortality factors
5. experimental assessment of the effects of river operations
6. efficacy of various habitat improvements
7. stock identification for salvage and ocean fishery management
8. constant fractional marking

The California Farm Bureau Federation (CFBF) submitted comments with several attachments calling for the removal of most salmonid ESUs from the endangered species list. The attachments included (1) an analysis by B.J. Miller showing that significant and expensive changes to water operations in the Delta provide fairly modest benefits to chinook populations; (2) “Reconsideration of the listing status of spring-run chinook salmon within the Feather River portion of the Central Valley ESU,” discussed in the preceding paragraph; (3) a memo from J. F. Palmisano to C.H. Burley arguing that because changes in marine climate have been shown to influence salmon stocks, other putative causes for declines of salmonid populations must be over-rated. CFBF reviews *Alsea Valley Alliance v. Evans* and argues that hatchery fish must be included in risk analyses.

New abundance data

The time series of abundance for Mill, Deer, Butte, and Big Chico creek spring chinook have been updated through 2001, and show that the increases in population that started in the early 1990s has continued (Figure A.2.9.4). During this period, there have been significant

Table A.2.9.1. Summary statistics for trend analyses. Numbers in parentheses are 0.90 confidence intervals.

Population	5-yr mean	5-yr min	5-yr max	λ	μ	LT trend	ST trend
Sac. R. winter chinook	2,191	364	65,683	0.97 (0.87, 1.09)	-0.10 (-0.21, 0.01)	-0.14 (-0.19, -0.09)	0.26 (0.04, 0.48)
Butte Cr. spring chinook	4,513	67	4,513	1.30 (1.09, 1.60)	0.11 (-0.05, 0.28)	0.11 (0.03, 0.19)	0.36 (0.03, 0.70)
Deer Cr. spring chinook	1,076	243	1,076	1.17 (1.04, 1.35)	0.12 (-0.02, 0.25)	0.11 (0.02, 0.21)	0.16 (-0.01, 0.33)
Mill Cr. spring chinook	491	203	491	1.19 (1.00, 1.47)	0.09 (-0.07, 0.26)	0.06 (-0.04, 0.16)	0.13 (-0.07, 0.34)

habitat improvements (including the removal of several small dams and increases in summer flows) in these watersheds, as well as reduced ocean fisheries and a favorable terrestrial climate.

The time series for Butte, Deer and Mill Creeks are barely amenable to simple analysis with the random walk-wth-drift model (Homes 2001, Lindley in press). The data series are short, and inconsistent methods were used until 1992, when a consistent snorkel survey was initiated on Butte and Deer Creeks. The full records for these three systems are analysed with the knowledge that there may be significant errors in pre-1992 observations. Table A.2.9.1 summarizes the analyses of these time series.

It appears that the three spring chinook populations in the Central Valley are growing. The current five-year geometric means for all three populations are also the maximum 5-year means. All three spring chinook populations have long and short-term $\lambda > 1$ (λ is defined as $\exp(\mu + \sigma^2_p / 2)$--the *mean* annual population growth rate in this document), with lower bounds of 90% confidence intervals generally > 1. Long- and short-term trends are also positive, although some confidence interval lower bounds are negative. Central Valley spring chinook have some of the highest population growth rates in the Central Valley, but other than Butte Creek and the hatchery-influenced Feather River, population sizes are relatively small compared to fall chinook populations (Figure A.2.9.5).

A.2.9.4 New Hatchery Information

FRH currently aims to release 5 million spring chinook smolts per year although actual releases have been mostly lower than this goal (Figure A.2.9.5). Returns to the hatchery appear to be directly proportional to the releases (Figure A.2.9.6).

A.2.9.5 Comparison with Previous Data

The upward trends in abundance of the Mill, Deer and Butte creek populations noted in the previous status review have apparently continued. New population genetics information confirms previous suspicions that Feather River hatchery and Feather River spring chinook are not closely related to the Mill, Deer and Butte creek spring chinook populations.

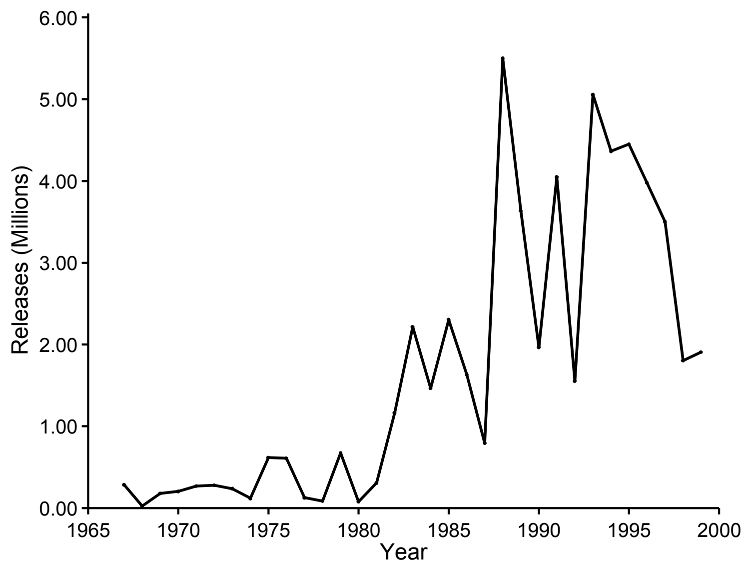

Figure A.2.9.5. Number of spring-run chinook released by Feather River Hatchery.

Figure A.2.9.6. Number of spring-run chinook returning to Feather River Hatchery.

A.3 PRELIMINARY CHINOOK BRT CONCLUSIONS

Snake River fall chinook

A majority of the BRT votes for this ESU fell in the "likely to become endangered" category, with minorities falling in the "danger of extinction," and "not likely to become endangered" categories. This represented a somewhat more optimistic assessment of the status of this ESU than was the case at the time of the original status review, when the BRT concluded that Snake River fall chinook salmon "face a substantial risk of extinction if present conditions continue" (Waples et al. 1991). The BRT found moderately high risks in all VSP elements, with mean risk matrix scores ranging from 3.0 for growth rate/productivity to 3.6 for spatial structure (Table A.3.1).

On the positive side, the number of natural-origin spawners in 2001 was well in excess of 1,000 for the first time since counts at Lower Granite Dam began in 1975. Management actions have reduced (but not eliminated) the fraction of fish passing Lower Granite Dam that are strays from out-of-ESU hatchery programs. Returns in the last 2 years also reflect an increasing contribution from supplementation programs based on the native Lyons Ferry Broodstock. With the exception of the increase in 2001, the ESU has fluctuated between approximately 500-1,000 adults, suggesting a somewhat higher degree of stability in growth rate and trends than is seen in other salmon populations.

In spite of the recent increases, however, the recent geometric mean number of naturally produced spawners is still less than 1,000, a very low number for an entire ESU. Because of the large fraction of naturally spawning hatchery fish, it is difficult to assess the productivity of the natural population. The relatively high risk matrix scores for spatial structure and diversity (3.5-3.6) reflect the concerns of the BRT that a large fraction of historic habitat for this ESU is inaccessible, diversity associated with those populations has been lost, the single remaining population is vulnerable to variable environmental conditions or catastrophes, and continuing immigration from outside the ESU at levels that are higher than occurred historically. Some BRT members were concerned that the efforts to remove stray, out-of-ESU hatchery fish only occur at Lower Granite Dam, well upstream of the geographic boundary of this ESU. Specific concerns are that natural spawners in lower river areas will be heavily affected by strays from Columbia River hatchery programs, and that this approach effectively removes the natural buffer zone between the Snake River ESU and Columbia River ocean-type chinook salmon. The effects of these factors on ESU viability are not known, as the extent of natural spawning in areas below Lower Granite Dam is not well understood, except in the lower Tucannon River.

Snake River spring/summer

The majority of BRT votes for this ESU fell in the "likely to become endangered" category, with minorities falling in the "danger of extinction," and "not likely to become endangered" categories. As indicated by mean risk matrix scores, the BRT had much higher concerns about abundance (3.6) and growth rate/productivity (3.5) than for spatial structure (2.2) and diversity (2.3) (Table A.3.1).

Although there are concerns about loss of an unquantified number of spawning aggregations that historically may have provided connectivity between headwater populations, natural spawning in this ESU still occurs in a wide range of locations and habitat types.

Like many others, this ESU saw a large increase in escapement in many (but not all) populations in 2001. The BRT considered this an encouraging sign, particularly given the record low returns seen in many of these populations in the mid 1990s. However, recent abundance in this ESU is still short of the levels that the proposed recovery plan for Snake River salmon indicated should be met over at least an 8-year period (NMFS 1995). The BRT considered it a positive sign that the non-native Rapid River broodstock has been phased out of the Grande Ronde system, but the relatively high level of both production/mitigation and supplementation hatcheries in this ESU leads to ongoing risks to natural populations and makes it difficult to assess trends in natural productivity and growth rate.

Upper Columbia spring chinook

Assessments by the BRT of the overall risks faced by this ESU were divided, with a slight majority of the votes being cast in the “danger of extinction” category, and a substantial minority in the “likely to be endangered” category. The mean risk matrix scores reflect strong ongoing concerns regarding abundance (4.4) and growth rate/productivity (4.5) in this ESU, and somewhat less (but still significant) concerns for spatial structure (2.9) and diversity (3.5) (Table A.3.1).

Many populations in this ESU have rebounded somewhat from the critically low levels that immediately preceded the last status review evaluation, and this was reflected in the substantial minority of BRT votes cast that were not cast in the “danger of extinction” category. Although this was considered an encouraging sign by the BRT, the last year or two of higher returns come on the heels of a decade or more of steep declines to all-time record low escapements. In addition, this ESU continues to have a very large influence by hatchery production, both from production/mitigation and supplementation programs. The extreme management measures taken in an effort to maintain populations in this ESU during some years in the late 1990s (collecting all adults from major basins at downstream dams) are a strong indication of the ongoing risks to this ESU, although the associated hatchery programs may ultimately play a role in helping to restore self-sustaining natural populations.

Lower Columbia River chinook

A majority of the BRT votes for this ESU fell in the “likely to become endangered” category, with minorities falling in the “danger of extinction,” and “not likely to become endangered” categories. Moderately high concerns for all VSP elements are indicated by mean risk matrix scores ranging from 3.2 for abundance to 3.9 for diversity (Table A.3.1).

All of the risk factors identified in previous reviews were still considered important by the BRT. The Willamette/Lower Columbia River TRT has estimated that eight to 10 historic populations in this ESU have been extirpated, most of them spring run. Near loss of that important life history type remains an important BRT concern. Although some natural production currently occurs in 20 or so populations, only one exceeds 1,000 spawners. High hatchery production continues to pose genetic and ecological risks to natural populations and to mask their performance. Most populations in this ESU have not seen pronounced increases in recent years as occurred in other geographic areas.

Upper Willamette River chinook

A majority of the BRT votes for this ESU fell in the "likely to become endangered" category, with minorities falling in the "danger of extinction," and "not likely to become endangered" categories. The BRT found moderately high risks in all VSP elements (mean risk matrix scores ranged from 3.1 for growth rate/productivity to 3.6 for spatial structure) (Table A.3.1).

Although the number of adult spring chinook salmon crossing Willamette Falls is in the same range (about 20,000–70,000) it has been for the last 50 years, a large fraction of these are hatchery produced. The score for spatial structure reflects concern by the BRT that perhaps a third of the historic habitat used by fish in this ESU is currently inaccessible behind dams, and the BRT remained concerned that natural production in this ESU is restricted to a very few areas. Increases in the last 3-4 years in natural production in the largest remaining population (the McKenzie) were considered encouraging by the BRT. With the relatively large incidence of hatchery fish, it is difficult to determine trends in natural production.

Puget Sound chinook

A majority of the BRT votes for this ESU fell in the "likely to become endangered" category, with minorities falling in the "danger of extinction," and "not likely to become endangered" categories. The BRT found moderately high risks in all VSP elements, with mean risk matrix scores ranging from 2.9 for spatial structure to 3.6 for growth rate/productivity (Table A.3.1).

Population indices have not changed dramatically since the last BRT assessment. The Puget Sound TRT has identified approximately 31 historic populations, of which nine are believed to be extinct, with most of the populations that have been lost being early run. Other concerns noted by the BRT are the concentration of the majority of natural production in just two basins, high levels of hatchery production in many areas of the ESU, and widespread loss of estuary and lower floodplain habitat diversity (and, likely, associated life history types). Although populations in this ESU have not experienced the sharp increases in the last 2-3 years seen in many other ESUs, more populations have increased than decreased over the 4 years since the last BRT assessment. After adjusting for changes in harvest rates, however, trends in productivity are less favorable. Most populations are relatively small, and recent abundance within the ESU is only a small fraction of estimated historic run size.

California Coastal chinook

A majority of the BRT votes for this ESU fell in the "likely to become endangered" category, with minorities falling in the "danger of extinction" and "not warranted" categories. The BRT found moderately high risks in all VSP elements, with mean risk matrix scores ranging from 3.1 for diversity to 3.9 for abundance (Table A.3.1).

The BRT was concerned by continued evidence of low population sizes relative to historical abundance and mixed trends in the few time series of abundance indices available for analysis, and by the low abundances and potential extirpations of populations in the southern part of the ESU. The BRT's concerns regarding genetic integrity of this ESU were moderate or low relative to similar issues for other ESUs because 1) hatchery production in this ESU is on a minor scale, and 2) current hatchery programs are largely focused on supplementing and restoring local populations. However, the BRT did have concerns with respect to diversity that were based largely on the loss of spring-run chinook in the Eel River basin and elsewhere in the ESU, and to a lesser degree on the potential loss of diversity concurrent with low abundance or extirpation of populations in the southern portion of the ESU. Overall, the BRT was strongly concerned by the paucity of information and resultant uncertainty associated with estimates of abundance, natural productivity and distribution of chinook salmon in this ESU.

Sacramento River winter chinook

A majority of the BRT votes fell into the "in danger of extinction" category, with minorities falling in the "likely to become endangered," and "not warranted" categories. The main VSP concerns were in the spatial structure (4.8) and diversity (4.2) categories, although there was significant concern in the abundance and productivity categories (3.7 and 3.5, respectively) (Table A.3.1).

The main concerns of the BRT relate to the lack of diversity within this ESU. The BRT was very troubled by the fact that this ESU is represented by a single population that has been displaced from its historic spawning habitat into an artificial habitat created and maintained by a dam. The BRT presumed that several independent populations of winter chinook were merged into a single population, with the potential for a significant loss of life history and genetic diversity. Furthermore, the population has passed through at least two recent bottlenecks—one when Shasta Dam was filled and another in the late 1980s-early 1990s—that probably further reduced genetic diversity. The population has been removed from the environment where it evolved, dimming its long-term prospects for survival. The BRT was modestly heartened by the increase in abundance since the lows of the late 1980s and early 1990s.

Central Valley spring chinook

A majority of the BRT votes fell into the "likely to become endangered" category, with minorities falling in the "in danger of extinction," and "not warranted" categories. There was roughly equal concern about abundance, spatial structure and diversity (3.5-3.8), and less concern about productivity (2.8) (Table A.3.1).

A major concern of the BRT was the loss of diversity caused by the extirpation of spring chinook populations from most of the Central Valley, including all San Joaquin tributaries. The only populations left in the Sierra Nevada ecoregion are supported by the Feather River hatchery. Another major concern of the BRT was the small number and location of extant spring chinook populations—only three streams, originating in the southern Cascades, support self-sustaining runs of spring chinook, and these three streams are close together, increasing their vulnerability to catastrophe. Two of the three extant populations are fairly small, and all were recently quite small. The BRT was also concerned about the Feather River spring chinook hatchery population, which is not in the ESU but does produce fish that potentially could interact with other spring chinook populations, especially given the off-site release of the production.

Table A.3.1. Summary of risk scores (1 = low to 5 = high) for four VSP categories (see section "Factors Considered in Status Assessments" for a description of the risk categories) for the nine chinook ESUs reviewed. Data presented are means (range).

ESU	Abundance	Growth Rate/ Productivity	Spatial Structure and Connectivity	Diversity
Snake River Fall	3.4 (2-5)	3.0 (2-5)	3.6 (2-5)	3.5 (2-5)
Snake River Spring/Summer	3.6 (2-5)	3.5 (3-5)	2.2 (1-3)	2.3 (1-3)
Upper Columbia Spring	4.4 (3-5)	4.5 (3-5)	2.9 (2-4)	3.5 (2-5)
Puget Sound	3.3 (2-4)	3.6 (3-4)	2.9 (2-4)	3.2 (2-4)
Lower Columbia	3.2 (2-4)	3.7 (3-5)	3.5 (3-4)	3.9 (3-5)
Upper Willamette	3.7 (2-5)	3.1 (2-5)	3.6 (3-4)	3.2 (2-4)
California Coastal	3.9 (3-5)	3.3 (3-4)	3.2 (2-4)	3.1 (2-4)
Sacramento Winter	3.7 (3-5)	3.5 (2-5)	4.8 (4-5)	4.2 (3-5)
Central Valley Spring	3.5 (3-4)	2.8 (2-4)	3.8 (3-5)	3.8 (3-5)

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A.5 APPENDICES

Appendix A.5.1. Preliminary SSHAG (2003) categorizations of hatchery populations of the nine chinook salmon ESUs reviewed. See “Artificial Propagation” in General Introduction for explanation of the categories.

	Stock	Run	Basin	SSHAG Category
Snake River fall	Lyons Ferry	Fall	Snake River	1 and 2
Snake River spring/summer	McCall (supplementation)	Spring	Salmon	1
	McCall (production)	Spring	Salmon	1 or 2
	Rapid River	Spring	Little Salmon	3
	Sawtooth	Spring	Salmon	2
	Pahsimeroi	Summer	Salmon	1 or 2
	Captive Broodstock			
	Catherine Creek	Summer	Grande Ronde	1
	Upper Grande Ronde	Summer	Grande Ronde	1
	Lostine River	Summer	Grande Ronde	1
	Clearwater	Spring	Clearwater	3
	Imnaha (# 29)	Spr/Sum	Imnaha	1
	Dworshak	Spring	Clearwater	3
	Kooskia	Spring	Clearwater	3
	Tucannon	Spring	Tucannon	1 or 2
Upper Columbia River spring	Leavenworth NFH	Spring	Wenatchee	3 or 4
	Entiat NFH	Spring	Entiat	3 or 4
	Winthrop NFH	Spring	Methow	3 or 4
	Chiwawa	Spring	Wenatchee	1
	Methow Composite			
	Twisp	Spring	Methow	1
	Chewuch	Spring	Methow	1
	Methow	Spring	Methow	3 or 4
	U. Columbia River Captive			
	Nason	Spring	Wenatchee	1
	White River	Spring	Wenatchee	1

	Twisp	Spring	Methow	1
	Methow	Spring	Methow	1
	Ringold Hatchery	Spring	U. Col. River	3 or 4
	Carson Hatchery	Spring	Wind	3 or 4
Puget Sound	Kendall Creek	Spring	Nooksack	2
	Lummi Bay	Fall	Nooksack	3
	Samish River	Fall	Samish	3
	Marblemount	Spring	Skagit	2
	Marblemount	Spring	Skagit	1
	Marblemount	Fall	Skagit	1
	Tulalip	Spring	Tulalip Bay	3
	Tulalip	Summer	Tulalip Bay	3
	Tulalip	Fall	Tulalip Bay	3
	N. Fork Stillaguamish	Summer	Stillaguamish	1
	Wallace River	Summer	Snohomish	2
	Issaquah Hatchery	Fall	Lake Washington	3
	UW Portage Bay	Fall	Lake Washington	3
	Soos Creek	Fall	Green	1 or 2
	Keta Creek	Fall	Green	1 or 2
	Grover's Creek	Fall	East Kitsap	3
	Garrison Springs	Fall	Chambers Creek	3
	Voights Creek	Fall	Puyallup	3
	Diru Creek	Fall	Puyallup	3
	White River	Spring	Puyallup	2
	Clear/Kalama Creeks	Fall	Nisqually	3
	Minter Creek	Fall	S. Sound	3
	Tumwater Falls	Fall	Deschutes	3
	George Adams	Fall	Skokomish	3
	WSC Hood Canal	Fall	Skokomish	3
	Finch Creek	Fall	S. Hood Canal	3
	Hamma Hamma	Fall	S. Hood Canal	3
	Big Beef Creek	Fall	N. Hood Canal	3
	Dungeness	Spring	Dungeness	1

	Elwha	Fall	Elwha	1 or 2
	Glenwood Springs	Fall	San Juan Islands	3
Lower Columbia River	Sea Resources	Fall	Chinook River	3
	Abernathy NFH	Fall	Abernathy Creek	3
	Grays River	Fall	Grays	3
	Elochoman	Fall	Elochoman	3
	Cowlitz	Fall	Cowlitz	2
	Cowlitz	Spring	Cowlitz	2
	Toutle	Spring	Cowlitz	3
	Kalama	Fall	Kalama	2
	Kalama	Spring	Kalama	3
	Lewis	Spring	Lewis	3
	Washougal	Fall	Washougal	2
	Carson	Spring	Wind	4
	LWS NFH	Fall	Little White	4
	Spring Creek NFH	Fall	Spring Creek	3 (or 2?)
	Klickitat	Fall	Klickitat	4
	Willamette	Spring	Youngs Bay	4
	Big Creek	Fall	Big Creek	3
	Rogue River (#52)	Fall	Youngs Bay	4
	Klaskanine (# 15)	Fall	Klaskanine	3
	Willamette	Spring	Klaskanine	4
	Bonneville (#14)	Fall	Gorge	3
	Bonneville (#95)	Fall	Gorge	4
	Hood River	Spring	Hood	4
Upper Willamette River	N. Fork Santiam (#21)	Spring	Santiam	3
	Willamette Hatchery (#22)	Spring	M. Fork Willamette	3
	McKenzie (#24)	Spring	McKenzie	2 or 3
	S. Fork Santiam (#23)	Spring	Santiam	3
	Clackamas (# 19)	Spring	Clackamas	3
California Coastal	Mad River	Fall	Mad River	3
	Freshwater Creek	Fall	Humboldt Bay	1

	Yaeger Creek	Fall	Van Duzen	1
	Redwood Creek	Fall	Redwood Creek	1
	Hollow Tree Creek	Fall	Eel River	1
	Van Arsdale	Fall	Eel River	1
	Mattole	Fall	Mattole River	1
Sacramento River winter chinook	Feather River	Spring	Feather River	4
California Central Valley spring	Feather River	Spring	Feather River	4

Appendix A.5.2. Lower Columbia Chinook Time Series References

Population	Big White Salmon River Fall Chinook
Years of Data, Length of Series	1964 - 2000, 37 years
Abundance Type	Peak Count
Abundance References	Rawding, Dan (WDFW). 2001a; Norman, G. 1982.
Abundance Notes	Abundance data are for adults and jacks. Estimates of spawner abundance are extrapolations made using peak count data and marking rate. 1980-200 data from Rawding. 1964-1979 data from streamnet reference (Norman)
Hatchery Reference	Rawding, Dan (WDFW). 2001a
Hatchery Notes	Hatchery data are part of the escapement data from Dan Rawding, WDFW.
Harvest Reference Stock	Spring Creek
Harvest Reference	Pacific Salmon Commission 2002
Harvest Notes	Estimated exploitation rate on hatchery stocks applied to natural stocks.
Age Reference	Rawding, Dan (WDFW).2001a.
Age Notes	Age distribution for 1982-1990 based on an average of 1991-2000.
Population	Clackamas River Fall Chinook
Years of Data, Length of Series	1967 - 2001, 35 years
Abundance Type	Peak Count
Abundance References	Oregon Dept of Fish and Wildlife. 1998.
Hatchery Reference	No Hatchery Data
Hatchery Notes	No Hatchery Data
Harvest Reference	No Harvest Data Available
Age Reference	Myers, et al.1998.
Age Notes	Generic fall age structure
Population	Coweeman River Fall Chinook
Years of Data, Length of Series	1964 - 2000, 37 years
Abundance Type	Peak Count
Abundance References	Rawding, Dan (WDFW). 2001a; Kreitman, G.. 1981.
Abundance Notes	Abundance data are for adults and jacks. Estimates extrapolated from peak count data and marking rate. 1964-1979 spawning data from Kreitman; 1980-2000 from Rawding.

Hatchery Reference	Rawding, Dan (WDFW). 2001a.
Hatchery Notes	Hatchery data are part of the escapement data from Dan Rawding, WDFW.
Harvest Reference Stock	Coweeman
Harvest Reference	Pacific Salmon Commission 2002.
Harvest Notes	Harvest data based on PFMC models provided by Dell Simmons.
Age Reference	Rawding, Dan (WDFW) 2001a.
Age Notes	Age distribution for 1980-1990 and estimate based on average from 1991-2000
Population	East Fork Lewis River Fall Chinook
Years of Data, Length of Series	1980 - 2000, 21 years
Abundance Type	Peak Count
Abundance References	Rawding, Dan (WDFW). 2001a.
Abundance Notes	Abundance data are for adults and jacks. Estimates of spawner abundance are extrapolations made using peak count data and marking rate.
Hatchery Reference	Rawding, Dan (WDFW). 2001a.
Harvest Reference Stock	Lewis Wild
Harvest Reference	Rawding, Dan (WDFW). 2001a.
Harvest Notes	AEQ ER for Lewis River from Dell Simmons
Age Reference	Rawding, Dan (WDFW).2001a.
Age Notes	Age distribution for 1980-1983 based on an average of 1984-2000
Population	Lewis River (Brights) Fall Chinook
Years of Data, Length of Series	1964 - 2000, 37 years
Abundance Type	Peak Count
Abundance References	Rawding, Dan (WDFW). 2001a. Kreitman, G.. 1981.
Abundance Notes	Abundance data are for adults and jacks. Estimates of spawner abundance are extrapolations made using peak count data and marking rate. 1964-1979 spawning data from Kreitman; 1980-2000 from Rawding.
Hatchery Reference	Rawding, Dan (WDFW). 2001a.
Hatchery Notes	Hatchery data are part of the escapement data from Dan Rawding, WDFW.
Harvest Reference Stock	Lewis Wild

Harvest Reference	Pacific Salmon Commission. 2002.
Harvest Notes	AEQ provided by Dell Simmons
Age Reference	Rawding, Dan (WDFW).2001a.
Age Notes	Age distribution for 1980-1990 and estimate based on average from 1991-2000
Population	Middle Gorge Tributaries Fall Chinook
Years of Data, Length of Series	1964 - 2000, 37 years
Abundance Type	Peak Count
Abundance References	Rawding, Dan (WDFW). 2001a; Norman, G. 1982.
Abundance Notes	Abundance data are for adults and jacks. Estimates of spawner abundance are extrapolations made using peak count data and marking rate. 1980-200 data from Rawding. 1964-1979 data from streamnet reference (Norman)
Hatchery Reference	Rawding, Dan (WDFW). 2001a.
Hatchery Notes	Hatchery data are part of the escapement data from Dan Rawding, WDFW.
Harvest Reference	No Harvest Data Available. . .
Age Reference	Rawding, Dan (WDFW).2001a.
Age Notes	Age distribution for 1980-1990 and estimate based on average from 1991-2000. Age distribution data missing for 1993
Population	Mill Creek Fall Chinook
Years of Data, Length of Series	1980 - 2000, 21 years
Abundance Type	Peak Count
Abundance References	Rawding, Dan (WDFW). 2001a.
Abundance Notes	Abundance data are for adults and jacks. Estimates of spawner abundance are extrapolations made using peak count data and marking rate.
Hatchery Reference	Rawding, Dan (WDFW). 2001a.
Hatchery Notes	Hatchery data are part of the escapement data from Dan Rawding, WDFW.
Harvest Reference Stock	Coweeman
Harvest Reference	Pacific Salmon Commission. 2002
Age Reference	Rawding, Dan (WDFW).2001a.
Age Notes	Age distribution for 1982-1990 based on an average of 1991-2000.
Population	Sandy River Fall Chinook

Years of Data, Length of Series	1988 - 2001, 14 years
Abundance Type	Total from redd count
Abundance References	Oregon Dept of Fish and Wildlife. 1998;
Abundance Notes	The estimate of spawning abundance is based on a one time peak count of live fish on the Sandy River. The index area is 10 miles from the mouth of Gordon Cr. To Lewis & Clark ramp. The number of fish is then multiplied by 2.5 to get the estimate (Streamnet ref # 50070). Fish counts are provided in Streamnet trend # 57517. Surveys were not conducted prior to 1988
Hatchery Reference	Oregon Dept of Fish and Wildlife. 1998.
Hatchery Notes	Michelle McClure (NOAA Fisheries) references ODFW for proportion of natural spawners
Harvest Reference	No Harvest Data Available
Age Reference	Myers, et al.1998.
Age Notes	Generic fall age structure
Population	Sandy River Late Fall Chinook
Years of Data, Length of Series	1984 - 2001, 18 years
Abundance Type	Total from redd count
Abundance References	Oregon Dept of Fish and Wildlife. 2002; Oregon Dept of Fish and Wildlife. 1990; Murtagh, T.; Massey, J.; Bennett, D.E. 1997.
Hatchery Reference	Oregon Dept of Fish and Wildlife. 1998.
Hatchery Notes	Michelle McClure (NOAA Fisheries) references ODFW for proportion of natural spawners
Harvest Reference	No Harvest Data Available.
Age Reference	Myers, et al.1998.
Age Notes	Generic fall age structure
Population	Washougal River Fall Chinook
Years of Data, Length of Series	1964 - 2000, 37 years
Abundance Type	Peak Count
Abundance References	Rawding, Dan (WDFW). 2001a; Kreitman, G.. 1981.
Abundance Notes	Abundance data are for adults and jacks. Estimates of spawner abundance are extrapolations made using peak count data and marking rate. 1964-1979 spawning data from Kreitman; 1980-2000 from Rawding.
Hatchery Reference	Rawding, Dan (WDFW). 2001a.
Hatchery Notes	Hatchery data are part of the escapement data from Dan Rawding, WDFW.

Harvest Reference Stock	Cowlitz Hatchery
Harvest Reference	Pacific Salmon Commission 2002.
Harvest Notes	AEQ provided by Dell Simmons
Age Reference	Rawding, Dan (WDFW).2001a.
Age Notes	Age distribution for 1982-1990 based on an average of 1991-2000.
Population	Kalama River Spring Chinook
Years of Data, Length of Series	1980 - 1999, 20 years
Abundance Type	Peak Count
Abundance References	Rawding, Dan (WDFW). 2001a.
Abundance Notes	Abundance data are for adults and jacks. Estimates of spawner abundance are extrapolations made using peak count data and marking rate.
Hatchery Reference	Rawding, Dan (WDFW). 2001a.
Hatchery Notes	Hatchery data are part of the escapement data from Dan Rawding, WDFW.
Harvest Reference	No Harvest Data Available.
Age Reference	No Age Data Available.
Population	Lewis River Spring Chinook
Years of Data, Length of Series	1980 - 1999, 20 years
Abundance Type	Peak Count
Abundance References	Rawding, Dan (WDFW). 2001a.
Abundance Notes	Abundance data are for adults and jacks. Estimates of spawner abundance are extrapolations made using peak count data and marking rate.
Hatchery Reference	Rawding, Dan (WDFW). 2001a.
Hatchery Notes	Hatchery data are part of the escapement data from Dan Rawding, WDFW.
Harvest Reference	No Harvest Data Available.
Age Reference	No Age Data Available.
Population	Upper Cowlitz River Spring Chinook
Years of Data, Length of Series	1980 - 1999, 20 years
Abundance Type	Peak Count
Abundance References	Rawding, Dan (WDFW). 2001a.

Abundance Notes	Abundance data are for adults and jacks. Estimates of spawner abundance are extrapolations made using peak count data and marking rate.
Hatchery Reference	Rawding, Dan (WDFW). 2001a.
Hatchery Notes	Hatchery data are part of the escapement data from Dan Rawding, WDFW.
Harvest Reference	No Harvest Data Available.
Age Reference	Myers, et al. 1998.
Population	Youngs Bay Fall Chinook
Years of Data, Length of Series	1950 - 2001, 52 years
Abundance Type	Fish/Mile
Abundance References	ODFW. 9999a.
Population	Big Creek Fall Chinook
Years of Data, Length of Series	1970 - 2001, 32 years
Abundance Type	Fish/Mile
Abundance References	ODFW. 9999a.
Population	Clatskanie River Fall Chinook
Years of Data, Length of Series	1970 - 2001, 32 years
Abundance Type	Fish/Mile
Abundance References	ODFW. 9999a.

Appendix A.5.3.
Upper Willamette Chinook Time Series References

Population	Clackamas River Spring Chinook
Years of Data, Length of Series	1958 - 2002, 45 years
Abundance Type	Dam/weir count
Abundance References	Cramer, Doug. 2002e.
Abundance Notes	Data are dam counts for NF Dam; adults only, production is mixed
Hatchery Reference	Cramer, Doug. 2002e.
Hatchery Notes	Counts of hatchery vs wild done only for 2001-2002 (Doug Cramer). Doug Cramner estimates the number of marked hatchery fish to be 50%.
Harvest Reference	No Harvest Data Available.
Age Reference	McClure, Michelle.2002.
Age Notes	Age distribution is taken from the Upper Willamette Chinook totals, not specific to Clackamas R Spring Chinook.

Population	Mckenzie River Spring Chinook
Years of Data, Length of Series	1970 - 2001, 32 years
Abundance Type	Dam/weir count
Abundance References	Kostow, Kathryn (ODFW). 2002b.
Abundance Notes	Data come from dam counts at Leaburg Dam. Spawning also occurs below the dam.
Hatchery Reference	Kostow, Kathryn (ODFW). 2002b.
Hatchery Notes	Hatchery fish have only been 100% marked in recent years. The hatchery marks are no6t 100% detectable at the dam because a portion of the hatchery fish are double index marked toevaluate the fishery impact to wild fish. Double index markes mean that the hatchery fish has a coded wire tag but it is not externally marked (that is, no fin clip). Therefore, the fish "looks wild" both to the fisherman (who must release the fish) and in the raw dam count. The McKenzie fish managers therefore do several expansions to deal with these issues.
Harvest Reference	No Harvest Data Available.
Age Reference	McClure, Michelle.2002.
Age Notes	Age distribution is taken from the Upper Willamette Chinook totals, not specific to McKenzie R Spring Chinook.

Population	Sandy River Spring Chinook
Years of Data, Length of Series	1977 - 2001, 25 years
Abundance Type	Dam/weir count
Abundance References	Cramer, Doug. 2002d.
Abundance Notes	Abundance estimates only
Hatchery Reference	No Hatchery Data.
Harvest Reference	No Harvest Data Available.
Age Reference	No Age Data Available.
Population	Willamette Falls Fall Chinook
Years of Data, Length of Series	1946 - 2001, 56 years
Abundance Type	Dam/weir count
Abundance References	Howell, P.J.. 1986; Bennett, D.E.. 1986; Bennett, D.E. and C.A. Foster. 1990; Bennett, D.E. and Foster, C.A.. 1994; Bennett, D.E. and C.A. Foster. 1995; Foster, C.A.. 1998.
Abundance Notes	2 additional references: Foster 2000 and Foster 2002. Data are for adults and jacks.
Population	Willamette Falls Spring Chinook
Years of Data, Length of Series	1946 - 2001, 56 years
Abundance Type	Dam/weir count
Abundance References	Anonymous. 1998; Foster, C.A.. 1998; Foster, C.A.. 2000.
Abundance Notes	Data are for adults and jacks.